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A DATE GARDEN IN CALIFORNIA

Successful Men Have Larger Families

Metaxenia—A Hormone Effect in Plants

JUNE, 1928 Vol. 19, No. 6

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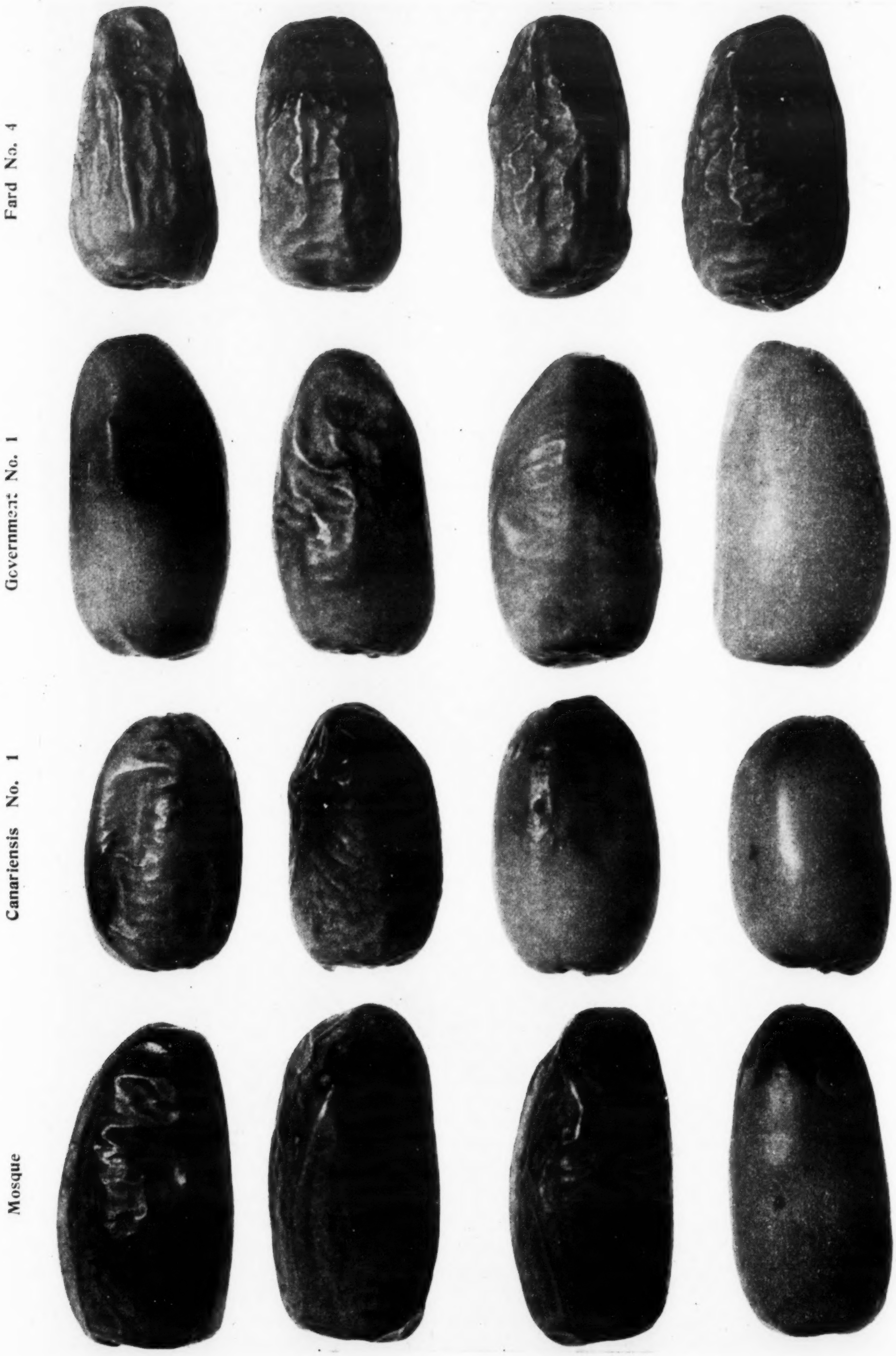


EFFECT OF POLLEN ON SIZE AND TIME OF RIPENING OF DATES

Frontispiece

Typical Deglet Noor dates produced by four kinds of pollen on the same cluster, pol-

IMMEDIATE INFLUENCE OF POLLEN

In Determining the Size and Time of Ripening of the Fruit of the Date Palm

ROY W. NIXON
Bureau of Plant Industry

STUDIES of the immediate influence of pollen on the fruit of the date palm were begun at the U. S. Experiment Date Garden, Indio, Calif., in February, 1925. Prior to the publication[5] of results obtained in these investigations there appears to be no record of experimental data on the subject. Schweinfurth[7] commented on the variability in the size of the seed, which he thought might be due to the influence of the male parent. Vinson[9] in discussing differences in ripening between certain palms at the Tempe Date Garden in Arizona suggested the possibility of an influence of pollen on the maturation of the pericarp. Bruce Drummond, when he was Superintendent of the U. S. Experiment Date Garden, observed differences in the size and time of ripening of the fruit, which he attributed to the use of different pollens. This was reported informally by Popenoe[6] but in the absence of detailed records of experiments safeguarded against any possible source of error, these supposed effects remained more or less dubious and amid the pressure of other problems more vital to the establishment of the new industry the lead was never followed up.

No doubt some of the native date growers in the Old World have come to believe in an immediate influence of the male parent, as mentioned by Popenoe[6]. There has likely been more foundation in their experience for such a belief than for the many myths and superstitions with which date culture is enshrouded there. But that there has been any general or definitely formulated recognition of a direct effect of pollen on the fruit is doubtful. Popenoe[6] states that in most Arab communities "the value of a male is judged solely by the amount of pollen it produces."

The writer was assured by V. H. W. Dowson of Basrah, who has had intimate contact with date growing in Mesopotamia, and by S. C. Mason of the U. S. Department of Agriculture, who has made extensive studies of date culture in Egypt, that they had never heard of a direct effect of pollen in these respective countries.

Of course, with the male palms as with the female, obvious differences among those grown from seeds have compelled attention. Because of wide variations in the time of blooming, size and number of inflorescences, quantity and percentage of germination of pollen produced, etc., many are of little or no value. It has also been recognized to some extent that with certain varieties pollen from one male may produce a better setting of fruit than that from another, tho both of the males might be of equal or varying potency as regards the setting produced on a fruiting palm of some other variety. This "compatibility" between male and female date palms has been mentioned by Mason[5]. No other factors seem to have governed the selection of palms for pollen. A few growers have suspected that the pollen might be responsible for ob-

---

linated the same day. The different pollens produced consistent differences in the size of the fruits and in their time of ripening, and this effect cannot be ascribed to xenia (immediate influence of pollen on the hybrid tissue of embryo and endosperm) because the effect is produced in entirely maternal tissue at some distance from the hybrid tissue of the seed.

Photo by Avery Edwin Field

A CALIFORNIA DATE GARDEN

Figure 1

A Deglet Noor Date garden at the beginning of the harvest. Similar palms were used for most of the pollination tests.

served differences in the size of seeds, but aside from that a good setting of fruit has generally been regarded as all that could be expected. The propagation of males from offshoots has not received the attention given to the fruit-bearing varieties.

As a basis of the experimental studies herein reported, two seedling males of *Phoenix dactylifera* growing at the Indio station were selected. One of these, Mosque, was grown from seed secured by S. C. Mason from a superior seedling palm near Kena, below Luxor, Egypt. It was selected because of the vigor of the palm and the exceptionally large inflorescences which contain an abundance of pollen. The other male, Fard No. 4, was grown from seed of imported fruit of the Fard variety, a small to medium-sized brownish-black date from eastern Arabia. It was selected because of the small size of the fruit and seed of the parent variety.*

In their botanical characters, as well as in the effects produced by their pollens, these two palms do not vary from numbers of others being used in commercial date gardens in the South-

*Dr. Walter T. Swingle, in charge of Federal date work in the Southwest, and under whose direction the experiments were begun, observed that a few of the dates from a seedling female nearby contained much smaller seeds than others on the same palm. These he suspected were produced by wind-blown pollen from Fard No. 4.

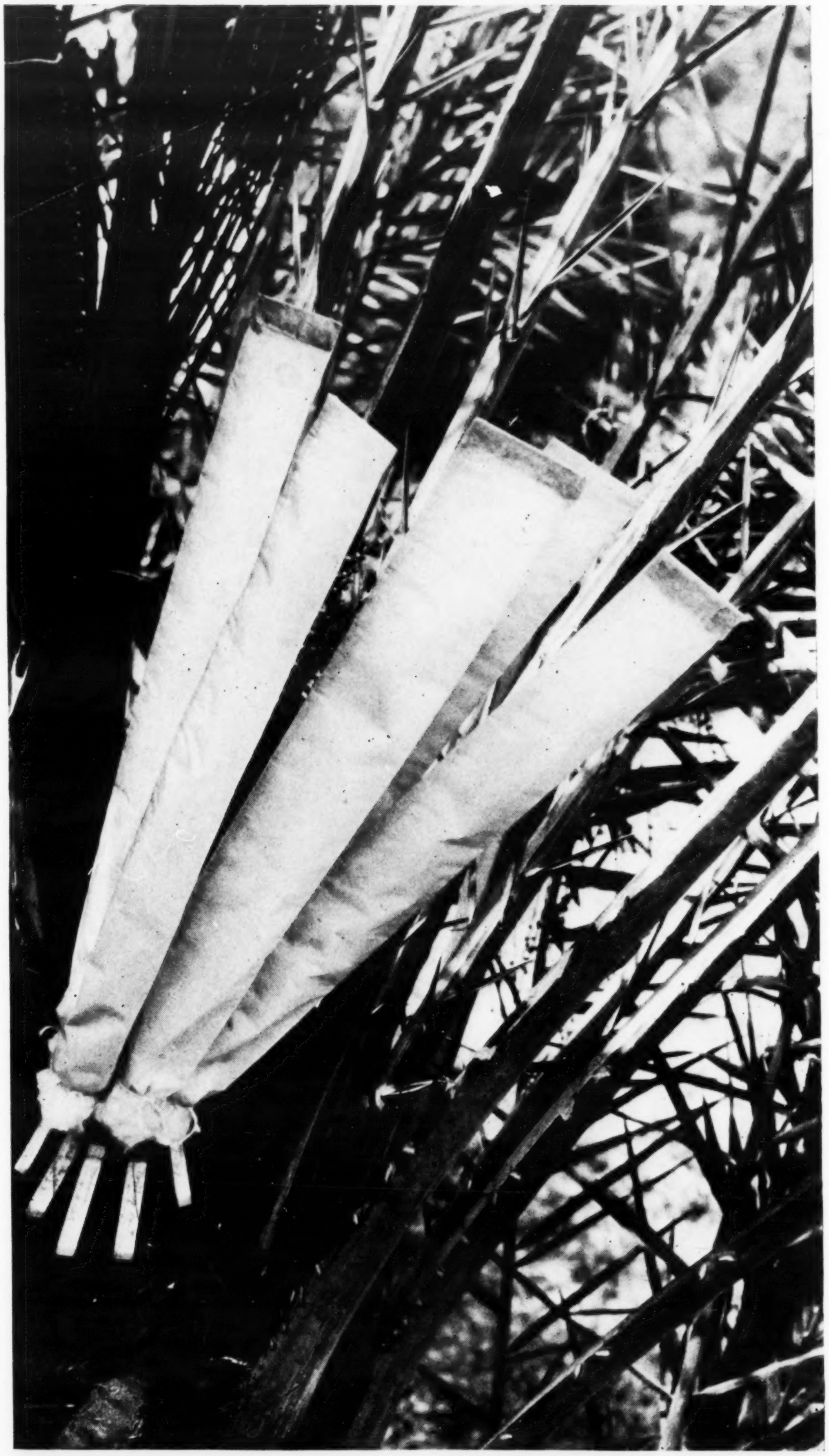
west more than the latter vary among themselves.

Technic of Pollination

The botanical peculiarities of the date palm and the anemophilous character of its floral structure render absolutely aseptic pollinations rather difficult under conditions prevailing in the field. The precautions used in carrying out these experiments are believed to have resulted in a nearly maximum purity of pollination. In securing pollen the male spathes for the most part were bagged before opening to exclude bees and insects. In all cases great care was exercised to prevent intermixture. When the pollen was not to be used immediately the inflorescences from each male were dried and stored in separate rooms. To avoid storage complications most of the pollens used in only one or two experiments were gathered, prepared and used immediately. After handling one pollen, whether gathering for storage or applying in the field, the operator was very careful to change clothes and to wash all portions of body exposed. Precautions were also taken with all implements used. During the first season the female inflorescences were pollinated early in the morning as soon as the first break in the spathe was observed. Unpollinated checks indicated that some contamination from foreign pollen might result from even a few hours exposure of the female flowers, so additional precautions were taken in subsequent experiments. Some of the female spathes were sponged with alcohol and covered with long, narrow glassine bags, through which the opening could be observed without danger of exposure until their removal at the time of pollination. Other spathes, which from their size appeared nearly mature, were forcibly opened for pollination. The results with the last method have been entirely satisfactory and it has been given preference in recent experiments.

Where one pollen was applied to an entire inflorescence the whole cluster was covered with a carefully made, long, narrow bag of heavy brown wrapping paper and plugged tightly with cotton at the base as far down in the axil of the leaf as possible. However, to secure identical conditions for the resulting fruit it is very desirable to apply the different pollens to different portions of the same cluster. Under such conditions greater care must be used to prevent contamination, but this is partly offset by the greater efficiency of bagging, for it is possible to put cotton all around each individual strand when only a few are used and there is no danger of subsequent exposure because of the growth of the fruit stalk—the bases of the flower strands are frequently far down in the axil of the leaf at the time the spathe first opens.

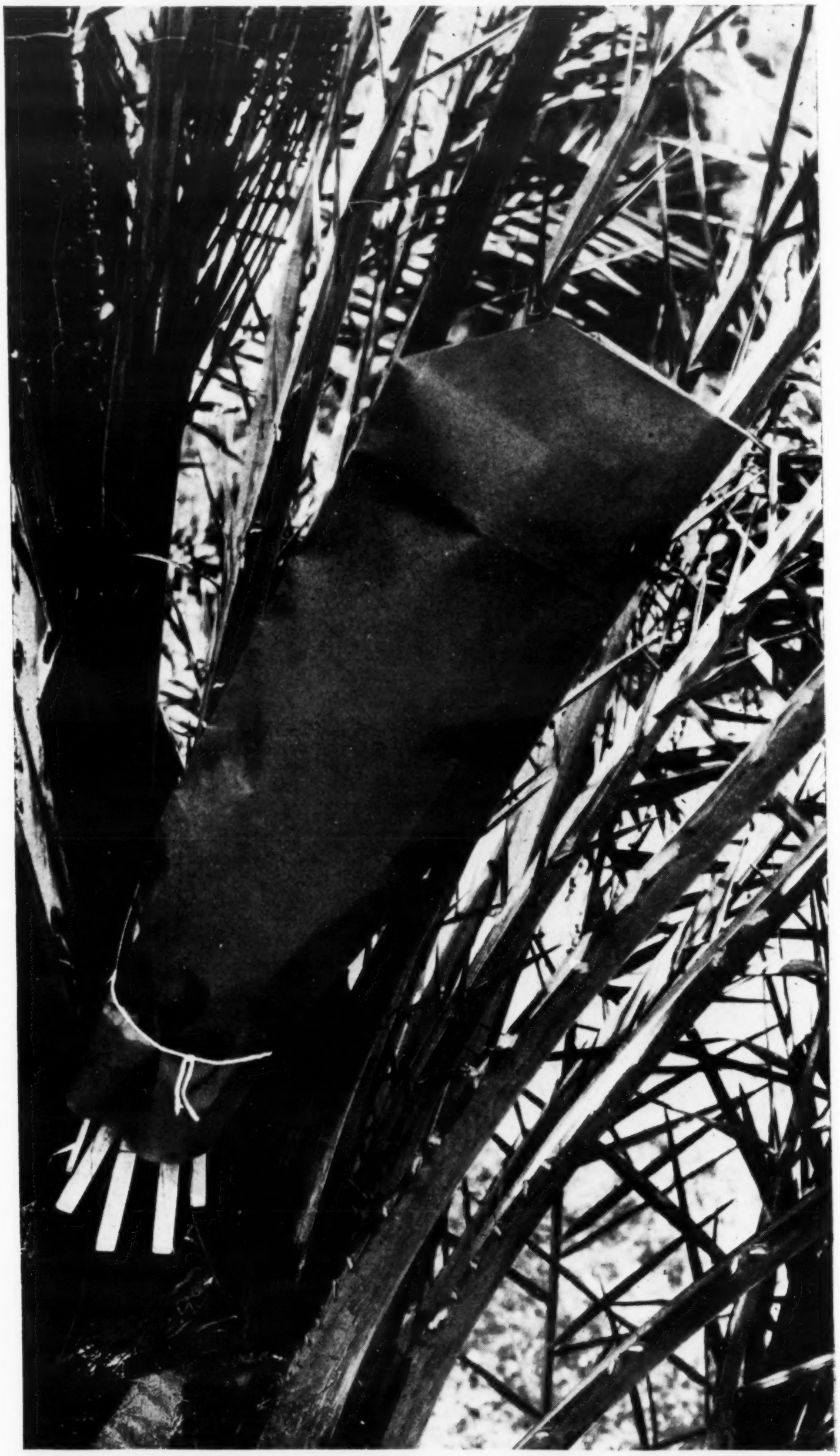
A method has been worked out for applying several pollens to different strands on the same inflorescence which greatly facilitates field work and insures a minimum of contamination. This consists in sealing the pollens in small packets, about 2½x5 inches, and glueing these small packets within the larger bags, about 3x24 inches, at the upper or sealed end. After the large bag has been placed over the strands to be pollinated and the lower or open end plugged with cotton and tied, the pollen is released by means of a long copper wire, one end of which is attached to a small piece of cotton sealed with the pollen in the small packet, while the other end passes through the cotton plug at the base of the strands to the outside. (See Figure 2). All of the bags are placed in position before pollination, which is accomplished by holding the upper end of the bag with one hand and pulling the lower end of the copper wire with the other, thereby breaking the small packet and liberating the pollen. The small packets used were made of heavy glassine paper, two thicknesses, each sealed separately, and before placing within the pollination bags they were washed off in a strong antiseptic solution. The 3"x24" bags



A NEW POLLINATION TECHNIC

Figure 2

The long glassene paper bags each enclose a single strand of the date inflorescence. (The base of another inflorescence is shown in the upper left part of the picture). In the upper end of each of the long bags is enclosed a smaller bag containing pollen which can be released by the trigger wires (shown at the base of the bags) after all the bags are in place.



THE POLLINATION COMPLETED

Figure 3

After the glassene bags are all in place(Figure 2) the pollen is released within them by pulling the trigger wires, and all the smaller bags are covered by a larger bag of heavy paper as an additional precaution against contamination. By this means it has been possible to carry on controlled pollination experiments using a number of kinds of the wind-blown date pollen with very slight danger of contamination.

were similarly made of two thicknesses of glassine paper, each sealed separately, and it was possible to observe the action of the wire plunger in effecting pollination. This method eliminates the necessity for direct contact with pollen in the field and the pistillate flowers are exposed only during the few moments while the bags are being placed in position. It effects a great saving in time when one pollen is to be used for a number of tests. By preparing them in this way one or more pollens can be safely carried about from one date garden to another and used as standards of comparison. One untested pollen may be safely applied by hand to another set of strands on the same bunch, covering with a 3″x24″ bag similar to the others. For additional protection a larger bag usually of heavy brown paper has been placed over the entire inflorescence, covering all of the small bags. Of course, it is necessary to remove carefully all spines on adjacent leaves. In most cases unpollinated checks indicated that the methods of bagging used afforded 100% insulation.

Summary of Experiments

Pollens from Mosque and Fard No. 4 were directly compared at the Indio station in eight experiments in 1925 and 22 in 1926, including nine tests in the Salt River Valley, Arizona. The data secured in 1925 and 1926 have already been reported in full.[5] The plan in 1927 was to secure preliminary readings on the behavior of as many untested pollens as possible, using Mosque and Fard No. 4 for comparison. Experiments were made not only at the U. S. Experiment Date Garden, but in a number of commercial gardens throughout the Coachella Valley, California, in several locations in the Salt River Valley, Arizona, and in the Gila River Valley, Arizona.

Readings were obtained from 58 experiments, in each of which the pollens represented were applied to different strands on the same inflorescence. Comparative data from the use of Mosque and Fard No. 4 together were obtained in 47 experiments. Of the total number of experiments all but 13 were on palms of the Deglet Noor variety in full commercial bearing. Up to the present time other varieties have been used for one or more experiments as follows: Rhars, Khadrawy, Iteema, Maktoom, Barhi, Tazizaout, Saidy, Hayany, Halaway, Tadala, and four seedlings. Comparable results were produced in every instance with all of the varieties tested.

The first outstanding difference in the effects produced by Mosque and Fard No. 4 pollens became noticeable about the middle or latter part of July. At this time in Coachella Valley the dates on the earliest inflorescences have nearly reached their maximum size and begin to change from green to a color characteristic of the stage preceding the final ripening. This color is usually some shade of red or yellow, the exact shade being more or less peculiar to the individual variety. For the Deglet Noor it is a bright coral red. In every experiment the dates from Fard No. 4 pollen colored ahead of those from Mosque, making a very striking display where side by side on the same bunch. These differences in coloring were followed by corresponding differences in ripening. In every experiment fruit from Fard No. 4 pollen matured earlier than that from Mosque.

In Table I are observations on the comparative coloring and ripening of fruit in 18 experiments at the U. S. Experiment Date Garden in 1927. In this series, representative of what has occurred repeatedly in other experiments, Mosque and Fard No. 4 pollens were included together in every test and not a single date with seed*

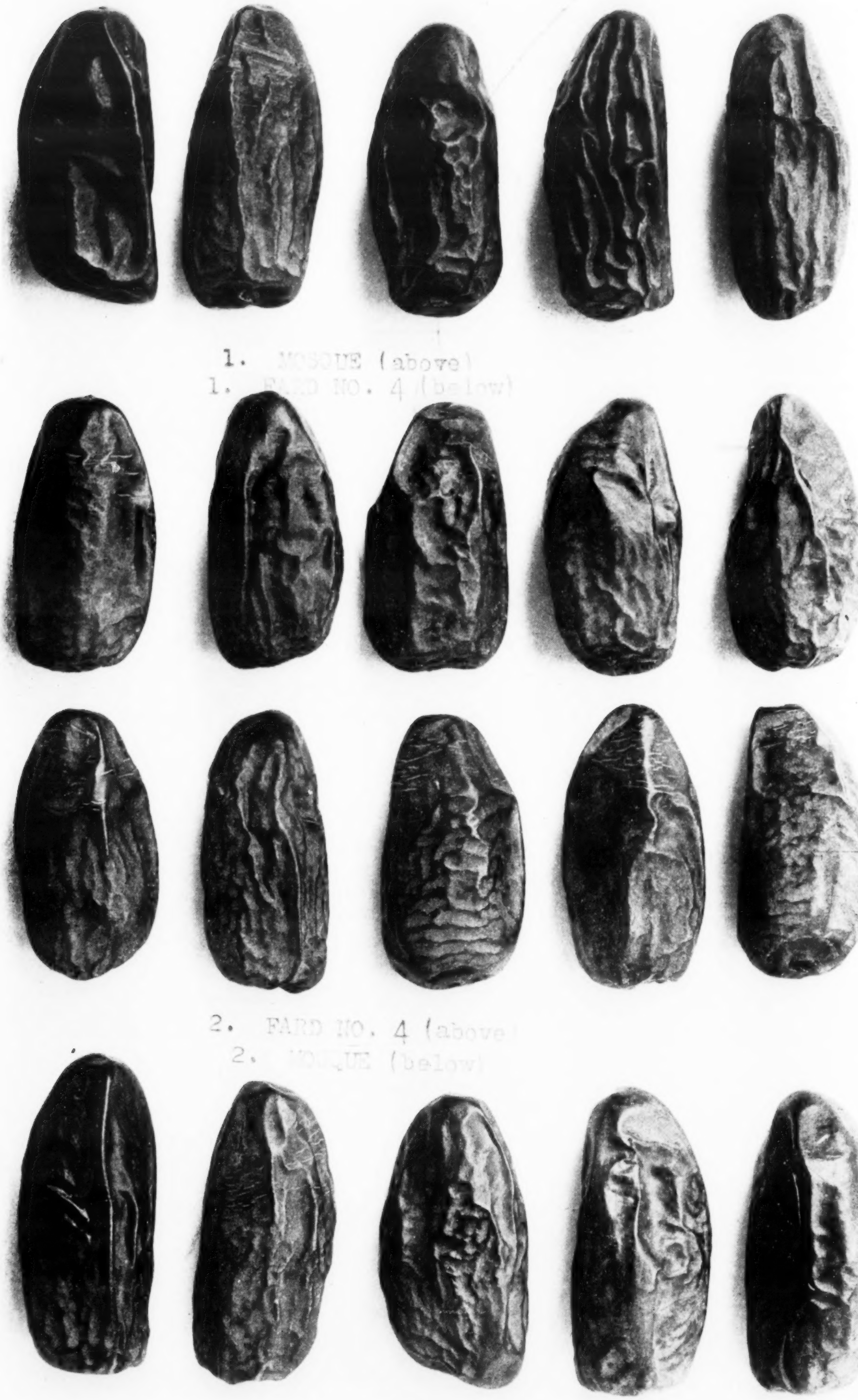
*In many varieties of dates the failure to receive pollen may result in a slight, more or less equal development of all three carpels. In the Deglet Noor variety one of the three carpels of an unpollinated flower frequently develops into a seedless date, usually smaller, of different shape and much later in developing.

developed in any of the unpollinated checks. The data are based on the total number of dates produced on an equal number of strands (3 or 4) in each experiment, a second total being taken at the first ripening observation. The tabulation of color differentiation is of course only approximate. The observations were not made at the optimum mid-period of initial color change in every case and the intensity of coloring also is a factor concerned, which incidentally may have a bearing either way because of differences in exposure. As a measure of the comparative ripening the ripe and partly ripe fruits are considered together as a percentage of the total, but in some cases a fairer evaluation is obtained by considering the two classifications separately. For instance, in Experiment 5 in the second observation on ripening there is a difference between Mosque and Fard No. 4 of only 10% in the percentage of ripe and partly ripe, which in this instance is largely due to the relatively large number of partly ripe dates in the Mosque. The percentage of ripe dates alone is 63 for Mosque and 87 for Fard No. 4. Again in Experiment 6 in the second observation on ripening all of the Fard No. 4 dates had probably been ripe for several days while nearly one-fourth of the Mosque dates were as yet only partly ripe. Also in Experiment 8 the second observation on ripening was made too late to catch significant differences. It is evident that for a limited number of observations those made after all the sets have begun to ripen and before any one of them has completed ripening afford the best index. However, because of the complicating factors usually involved any mathematical expression of such a process as ripening must be regarded as more or less flexible, and of course the smaller the difference observed the greater the number of experiments necessary to prove its significance. Fluctuations were expected. The surprising thing about these experiments has been the degree of consistency.

The 1927 results not only abundantly confirm the findings of the two previous years as to Mosque and Fard No. 4, but also what was previously indicated—that among the male palms now being used in commercial gardens there are others whose pollens will produce similar effects.

There are 25 other pollens included in the series of experiments covered by Table I. With all gradations and numerous fluctuations any division must be more or less arbitrary, but it is evident that the fruit from some ripened much like the Mosque and that from others like the Fard No. 4. In the former class may be included Cast's No. 1, 2-12-8, Canariensis No. 6, Unknown-N, Saidy 25-ND, Deglet Noor N-9, Deglet Noor N-16 and Deglet Noor N-18; in the latter, Fard No. 5-B, Fard FNJ-N, P.S. No. 2, P.S. No. 6, P.S. No. 8, Zaheedy A-18-2-C-6 and C x R No. 13. One of these, Canariensis No. 6, represents a different species of *Phoenix* and another, C x R No. 13, represents a hybrid palm grown from seed of the Rhars variety pollinated with *Phoenix canariensis* pollen. Canariensis No. 6, in other experiments as well as the one included in Table I, definitely produced late ripening. Two out of three other Canariensis pollens previously tested on Deglet Noor also produced late ripening—a little later even than Mosque, and the third, while producing somewhat earlier ripening than Mosque, could not be classed with Fard No. 4. C x R No. 13, on the other hand, produced ripening comparable to Fard No. 4.

It will be noted that the setting of fruit obtained with pollen from the hybrid palm was less than half that secured with the other pollens. Whether this low setting was due to a lack of "compatibility" or to the fact that the hybrid male is still a small, young palm, may be questioned. Incompatibility appears to be involved



1. MOSQUE (above)
1. FARD NO. 4 (below)

2. FARD NO. 4 (above)
2. MOSQUE (below)

Figure 4 *(Legend next page)*

1. MOSQUE (above)

1. FARD NO. 4 (below)

2. FARD NO. 4 (above)

2. MOSQUE (below)

Photographs by E. L. Crandall

EFFECT OF POLLEN ON SIZE OF FRUIT AND SEED

Figure 5

On the adjoining page are shown Deglet Noor Dates produced by two kinds of pollen on different parts of the same strand, in two experiments. Above (Fig. 5) are shown the seeds from these dates (and from one more row omitted on the left in figure 4). The fruits produced by the Mosque pollen are consistently larger and ripen considerably later than those produced by pollen of Fard No. 4. The fleshy part of the date is entirely maternal tissue, and thus the influence of the pollen on it cannot be ascribed to xenia, a well-recognized phenomenon in the hybrid tissue of embryo and endosperm.

in the low setting of fruit from Canariensis No. 6 pollen in Experiment 2. Every pollen of this species tested so far has produced a low setting on Deglet Noor, while in several experiments on the Rhars variety the results were reversed and the *canariensis* pollens produced much better settings than the *dactylifera*. While exceptions have continually occurred, taking three years of experiments as a whole a tendency has been noted for Mosque to give a better setting than Fard No. 4 on the Deglet Noor variety—a probable instance of varying compatibility within the species, both pollens also producing what would be considered good commercial settings.

The effect of enclosing an inflorescence with its developing fruit in a tight bag for four to six weeks, as was done in these experiments, was put to test in a number of experiments in 1927. Nos. 12, 13 and 15 in Table I contained one set of strands which was a duplicate of one of the other pollinations except that it was not enclosed in a bag of any kind, being also left outside the protecting hood or bag placed over the remainder of the inflorescence. The results from these treatments, designated by the letters "OP" (open pollinated) indicated that there was a slight stimulus to ripening produced by the bags themselves. Because of the obvious exposure to foreign pollen further data are needed, but this is an experiment in itself. The experimental conditions were the same for all of the pollens compared as to their effect on the fruit.

As a climax to the accumulation of evidence of the direct effect of pollen Mosque and Fard No. 4 pollens with extra precautions were applied to different parts of the same strands in two experiments on the same inflorescence of a Deglet Noor palm in 1927. The resulting fruit showed typical differences in coloring and ripening. (See Table II). With the exception of a few specimens sent away for photographs, some of which are shown in Figure 4, all of the dates were measured to the nearest millimeter and the seeds to the nearest one-tenth millimeter. A summary of these measurements is given in Table III. While the differences in the size of the seeds are more significant than those of the fruits in at least one dimension in each experiment the fruits show a significant difference. That these differences in size are fairly typical of those which have obtained in three years of experiments will be seen from a comparison with Table IV. This table is a summary of the average mean differences produced by Mosque and Fard No. 4 pollens on Deglet Noor fruit and seed in 62 experiments, the first two years' results being compared to the third. In the former series 30 to 100 measurements, all to the nearest millimeter, were made in each experiment with the exception of nine experiments in which only ten measurements each were made; in the latter series ten measurements each were made, to the nearest millimeter for the fruit and the nearest tenth millimeter for the seed. In nine of the first two years' experiments successive inflorescences on the same palm were each pollinated with a different pollen. In all of the 1927 experiments the pollens were applied to different strands on the same bunch. The significance of such consistent differences is evident with any biometric criteria. Their existence has been obvious to date growers and other observers who have seen the experiments in the field.

That these differences in size were accompanied by differences in the net dry weight of the flesh produced is indicated by the results of ten determinations in 1927, given in Table V. This represents ten experiments and eight different palms. Nos. 4 and 5 were on the same palm; Nos. 2 and 8 on another. As 100 fruits were not available in these experiments, the data

Photograph by E. L. Crandall

SIZE AND SHAPE DIFFERENCES IN DEGLET NOOR SEED PRODUCED BY DIFFERENT POLLENS

Figure 6

The first three rows from the bottom were produced on different strands on the same inflorescence. The other seed came from different bunches on the same palm. The male tree C×R No. 9 is a hybrid between the Rhars variety of *Phoenix dactylifera* and *P. canariensis*. Note that the seed produced by this pollen has the tapering base characteristic of the seed produced by *canariensis* pollen. The depression around the germ pore on the dorsal side of the seed produced by pollen of *P. Roebellenii* is a peculiarity noted in none of the other pollens used, and these fruits were the last to mature.

were calculated from lots of 20 each. which were weighed, ground and the percentage of moisture in a 20-gram sample found by distillation, using the method outlined by Bidwell and Sterling[1] and the net dry weight secured by subtraction. The seeds taken from the 20 dates were weighed in each case and are the basis for the data given in Table VI.

The significance of the weight data may be brought out by the criterion of "Student's Method," which is particularly applicable to a limited number of paired experiments. The use of the method has been discussed by Love and Brunson[2,3]. It is based on the ratio of the mean difference to the standard deviation. Tables have been worked out for the significance of these ratios.

The mean difference in the net dry weight of flesh only per 100 dates from Table V is 67.39 ± 7.67, standard deviation 33.18 ± 5.00. From Table VI the mean difference in the weight of the seed per 100 is 40.57 ± 2.41, standard deviation 10.43 ± 1.57. While the seed difference is more significant than the flesh difference, in both cases the odds are more than 9999 to 1 against such a difference occurring from chance. Nine determinations in 1926 gave equally significant differences. The fluctuations in weight difference have not yet been correlated with any other factors involved in the experiments.

As regards the size in relation to the time of ripening of the fruit, while the correlation is not exact, among the male palms of *Phoenix dactylifera* tested so far the pollens which produced early ripening produced smaller fruit and seed than those which produced late ripening. On the other hand, the smallest fruit and seed produced in any of these tests were from pollen of *Phoenix canariensis,* which, as already mentioned, caused late ripening. In addition to their small size, seeds from pollens of this species were characterized by a peculiar tapering base (see Figue 6), which made them readily distinguishable from the seed produced by other pollens. Some of the seed produced by hybrid *canariensis dactylifera* pollen also showed this tapering tendency to a lesser degree (see Figue 6).

The most pronounced effect that has yet been produced resulted from the use of a small lot of pollen of *Phoenix Roebelenii* from a palm at the Royal Palm Nurseries, Oneco, Fla. It was received late in the pollination season and applied to an entire Deglet Noor inflorescence on April 25, 1927. Nothing unusual was observed about the fruit until the ripening of Deglet Noor dates in the garden was well advanced, when it began to attract attention because of its delayed maturity. On Nov. 19 only about 5% of the fruit was estimated to be ripe, while on another bunch on the same palm, pollinated with mixed pollen on April 21, four days previous, all of the fruit was full ripe. Mosque, which has consistently produced late-ripening fruit, was included in the mixed pollen. On December 5 out of a total of 317 dates (the bunch was a small one and the setting below normal for *dactylifera* pollen) 56 (18%) were ripe, 105 (33%) partly ripe and 156 (49%) immature. All of the other Deglet Noor fruit in the garden had been picked by this date. How long it would have taken for all of the dates to ripen can only be conjectured. The bunch was cut off through mistake by a Mexican laborer, who was removing the season's fruit stalks. The fruit did not appear different from that produced by other pollens on Deglet Noor. The average measurements of 20 were: fruit, length—$41.0 \pm .31$ mm, breadth—$20.4 \pm .13$ mm; seed, length—$25.1 \pm .27$ mm. breadth—$7.5 \pm .09$ mm. The seeds were rather irregular in proportions. They were characterized by a smaller germ pore than the normal seeds from other pollens and out of 293 examined, 103 (35%) possessed a

peculiar dorsal depression of which the germ pore was the center. This depression varied in size and shape, but tended to be circular and apparently was produced by some inhibition in the development of the endosperm in the vicinity of the embryo. Some of these seeds are shown in Figure 6. This striking peculiarity has never appeared on any of the thousands of date seeds of all varieties examined by the writer in the past five years.

The seeds produced by the pollen of *P. Roebelenii*, however, have given only feeble germination. Seeds from other pollens used, including *P. canariensis*, have given good germination and growth.

Aside from its influence on the size and time of ripening of the fruit no other effects have so far been traced to pollen. In individual experiments there have been differences in texture, but taking all the experiments as a whole, such differences have been about as often in opposite directions. Of two lots of fruit ripening at different times one could very easily be softer than the other due to a difference in the relative humidity at the time of ripening. Sugar analyses of fruit resulting from different pollens including *Phoenix Roebelenii*, have been made in several experiments, but no significant differences appeared. The likelihood that pollen has any direct effect on the sugar of the date is further lessened by the fact that the sugar content of two samples of unpollinated Deglet Noor dates, one in 1925 and one in 1926, which finally ripened about three months after those which received pollen, varied less than two per cent from that of the nearest pollinated fruit.

Summary

Experimental data for three years in the Coachella Valley, Calif., with two years of supplementary tests in Arizona, chiefly in the Salt River Valley, have given consistent evidence that the time of ripening of date fruit, as well as the size of both fruit and seed, may be directly affected by the pollen used.* The possibility of being able to influence the time of ripening by the use of selected pollens is likely to be of vast importance in the development of the date industry in new regions. Where the seasonal margins are rather sharply defined a difference of ten days or two weeks, which has been repeatedly produced under experimental conditions by pollens from two seedling *dactylifera* males and demonstrated to be possible with pollens from many others, may be the difference between success and failure with certain varieties. And as a factor in determining the size of the fruit and seed the grower in the future will be able to use pollen with discretion as an aid to cultural practices in producing high-grade, standardized fruit.

*For the direct effect of pollen on the tissues of the mother plant outside the embryo and endosperm, Walter T. Swingle has proposed the term "metaxenia," first in a report and discussion of the evidence at the meeting of the Southwestern Division of the American Association for the Advancement of Science at Phoenix, Ariz., Feb. 15-18, 1926. Later a more complete discussion was presented in two papers[3] read by Swingle before the International Congress of Plant Sciences at Ithaca, N. Y., August 16-23, 1926, abstracts of which appear in the proceedings of the Congress.

More recently Swingle has further elaborated this explanation in a paper entitled "*Metaxenia in the date palm, possibly a hormone action exerted by the embryo or endosperm;* presented April 24, 1928, at the Annual Meeting of the National Academy of Sciences, Washington, D. C.

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TABLE I—Comparative Coloring and Ripening of Dates in Eighteen Experiments—1927

Experiment	Palm	Date of pollination	Pollen	Date of observation	Total number of dates	Showing characteristic pre-ripe color	Percentage showing characteristic pre-ripe color	Date of observation	Total number of dates	Ripe	Partly ripe	Percentage ripe & partly ripe	Date of observation	Ripe	Partly ripe	Percentage ripe & partly ripe
No.1	Deglet Noor 2-6-3	Mar.7	Mosque	Jul.29	132	24	18	Aug.27	82	0	0	0	Sep.21	19	5	29
			Fard No.4	"	133	129	97	"	93	7	6	14	"	60	7	72
			Gast's No.1	"	46	12	26	"	43	1	1	5	"	8	5	30
			2-12-8	"	50	16	32	"	42	1	2	7	"	8	0	19
No.2	" " "	Mar.17	Mosque	Aug.3	111	43	39	Aug.29	87	0	2	2	Sep.19	31	6	43
			Fard No.4	"	85	82	96	"	83	0	12	14	"	58	10	82
			Canariensis No.6	"	47	35	74	"	43	0	0	0	"	13	2	35
			P.S. No.2	"	74	68	92	"	69	6	7	19	"	51	8	86
No.3	" " "	Mar.17	Mosque	Aug.3	134	61	46	Aug.29	134	0	6	5	Sep.21	61	17	58
			Fard No.4	"	100	99	99	"	96	5	26	32	"	91	3	98
			Fard No.5-B	"	80	74	93	"	75	5	5	13	"	52	9	81
			99-22-H	"	141	68	48	"	136	0	17	13	"	73	13	63
No.4	" " "	Apr.7	Mosque	Aug.15	101	60	59	Sep.15	92	0	5	5	Sep.24	1	7	9
			Fard No.4	"	82	80	98	"	72	7	15	31	"	42	7	68
			Tafilet-H	"	116	114	98	"	114	5	13	16	"	49	23	63
			Freak Male SC	"	113	75	66	"	113	2	7	8	"	18	20	34
No.5	Deglet Noor 2-5-7	Mar.19	Mosque	Aug.4	111	18	16	Sep.16	81	2	4	7	Oct.6	51	13	79
			Fard No.4	"	90	88	98	"	82	20	15	42	"	71	2	89
			Menakher A16-1-58	"	121	68	56	"	103	26	12	37	"	92	6	95
No.6	" " "	Apr.4	Mosque	Aug.4	36	7	19	Sep.9	36	0	9	25	Sep.24	23	8	86
			Fard No.4	"	37	34	92	"	33	15	7	66	"	33	0	100
			King-G	"	67	35	52	"	67	10	11	31	"	52	7	88
			Zaheedy A18-206	"	31	27	87	"	30	6	12	60	"	26	0	87
No.7	" " "	Apr.13	Mosque	Aug.15	85	55	65	Sep.16	78	0	5	6	Oct.8	36	10	59
			Fard No.4	"	63	60	95	"	61	4	12	26	"	51	6	93
			Deglet Noor N-1	"	103	80	74	"	102	1	8	9	"	71	11	80
			P.S. No.6	"	46	43	93	"	45	1	8	20	"	37	7	98
No.8	Deglet Noor 1-5-10	Mar.19	Mosque	Jul.30	49	7	14	Aug.29	49	0	5	10	Sep.21	43	4	95
			Fard No.4	"	51	47	92	"	47	9	15	51	"	47	0	100
			Saidy 14 ND	"	79	16	20	"	74	5	5	14	"	73	0	99
			Deglet Noor N-12	"	53	26	49	"	46	3	9	26	"	45	1	100
No.9	" " "	Mar.22	Mosque	Aug.4	54	21	39	Sep.9	54	5	7	22	Sep.21	23	12	65
			Fard No.4	"	50	50	100	"	45	31	11	93	"	45	0	100
			Deglet Noor N-9	"	17	9	53	"	16	4	1	31	"	11	1	75
			Deglet Noor N-16	"	69	41	59	"	65	12	6	28	"	44	6	77
No.10	" " "	Apr.18	Mosque	Aug.15	89	60	67	Sep.16	89	1	10	12	Sep.24	28	10	43
			Fard No.4	"	73	72	99	"	73	25	11	49	"	55	14	95
			Deglet Noor N-9	"	75	47	63	"	75	3	8	15	"	16	8	32
			C x R No.13	"	35	34	97	"	34	7	14	62	"	28	3	91
No.11	Deglet Noor 2-14-7	Apr.7	Mosque	Aug.15	67	40	60	Sep.15	67	3	2	7	Sep.24	12	8	30
			Fard No.4	"	53	50	94	"	53	14	7	40	"	34	7	77
			Tafilet-R	"	67	66	99	"	56	5	9	25	"	36	9	80
			Fard FNJ-N	"	62	60	97	"	62	6	10	26	"	38	10	77
No.12	Deglet Noor 2-7-6	Apr.13	Mosque	Aug.15	41	19	46	Sep.15	39	0	0	0	Sep.24	2	10	31
			Fard No.4	"	41	40	98	"	38	3	13	42	"	26	6	84
			Unknown-N	"	68	41	60	"	66	0	3	5	"	12	8	30
			Fard FNJ-N	"	53	48	90	"	53	11	17	53	"	39	4	81
			Fard FNJ-N-OP	"	59	56	95	"	57	3	7	18	"	28	8	63
No.13	Deglet Noor 2-15-7	Apr.18	Mosque	Aug.15	71	15	21	Sep.15	71	0	0	0	Oct.8	28	8	51
			Fard No.4	"	40	37	93	"	39	4	11	38	"	36	1	95
			Deglet Noor N-18	"	91	35	38	"	91	1	4	5	"	29	13	46
			" " N-18-OP	"	92	21	23	"	92	0	1	1	"	19	8	29
No.14	" " "	Apr.18	Mosque	Aug.15	19	5	26	Sep.15	17	0	0	0	Sep.24	4	1	29
			Fard No.4	"	50	47	94	"	50	16	13	58	"	44	2	92
			P.S. No.8	"	39	36	92	"	26	4	8	46	"	19	4	68
			Rhars 643-B	"	53	39	74	"	53	2	6	15	"	28	10	72
No.15	Deglet Noor 2-6-1	Mar.22	Mosque	Aug.4	44*	16	36	Sep.9	41	1	10	27	Sep.21	24	7	76
			Fard No.4	"	102	100	98	"	100	29	36	65	"	97	1	98
			Saidy 25-ND	"	124	96	97	"	118	13	13	22	"	68	19	74
			Deglet Noor N-1	"	108	76	70	"	108	17	9	24	"	63	16	73
			" " " OP	"	48*	17	35	"	46	1	2	7	"	15	15	65
No.16	Hayany 1-1-9	Apr.19	Mosque	Jul.30	37	37	†100	Aug.26	37	4	2	16	Sep.10	18	1	51
			Fard No.4	"	29	29	†100	"	25	8	1	36	"	16	1	66
No.17	Halawy 2-11-8	Apr.23	Mosque	Aug.11	82	48	59	Aug.26	79	0	10	13	Sep.10	32	12	56
			Fard No.4	"	87	83	95	"	77	28	13	53	"	63	9	94
			Menakher A25-1-37	"	87	78	90	"	80	15	11	33	"	59	9	85
No.18	Barhi 1-2-5	Mar.19	Mosque	Aug.4	17	4	14	Aug.29	15	0	0	0	Sep.10	2	1	20
			Fard No.4	"	15	10	67	"	14	1	2	21	"	9	1	71
			Saidy 14 ND	"	14	8	57	"	12	0	1	8	"	5	2	58

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TABLE II—The Effect of Different Pollens on the Coloring and Ripening of Deglet Noor Dates when Applied to Different Parts of the Same Strands in Two Experiments on the Same Bunch. (All Pollinated the same day, March 22, 1927), palm 2-7-6, U. S. Experiment Date Gardens, Indio, California.

			July 29			August 25				September 10		
Experiment	Pollen	Relative position of dates pollinated	Total number of dates	Showing reddish tints	Percentage showing reddish tints	Total number of dates	Ripe	Partly ripe	Percentage ripe and partly ripe	Ripe	Partly ripe	Percentage ripe and partly ripe
No.1	Fard No.4	above	27	19	70	26	12	2	54	26	0	100
	Mosque	below	47	1	2	43	0	3	7	26	7	77
No.2	Mosque	above	35	2	6	34	0	0	0	19	5	71
	Fard No.4	below	44	17	39	37	9	7	43	32	0	86

TABLE III—Effect of Different Pollens on the Size of Deglet Noor Fruit and Seed when Applied to Different Parts of the Same Strands in Two Experiments on the Same Bunch.

Exp. No. 1	Mosque - below (39 measurements)	Fard No.4 - above (21 measurements)	Difference
Mean fruit length	42.0 ± 0.25 mm.	40.6 ± 0.28 mm.	1.4 ± 0.37 mm.
Mean fruit width	20.8 ± 0.12 "	19.2 ± 0.17 "	1.6 ± 0.21 "
Mean seed length	25.4 ± 0.16 "	22.8 ± 0.17 "	2.6 ± 0.28 "
Mean seed width	8.4 ± 0.05 "	7.0 ± 0.06 "	1.4 ± 0.08 "
Exp. No. 2	**Mosque - above (28 measurements)**	**Fard No.4 - below (31 measurements)**	**Difference**
Mean fruit length	44.0 ± 0.26 mm.	40.4 ± 0.24 mm.	3.6 ± 0.35 mm.
Mean fruit width	20.1 ± 0.14 "	20.3 ± 0.11 "	-0.2 ± 0.18 "
Mean seed length	26.3 ± 0.29 "	23.5 ± 0.31 "	2.8 ± 0.36 "
Mean seed width	8.1 ± 0.05 "	7.6 ± 0.08 "	0.5 ± 0.10 "

TABLE IV—Average Mean Difference Produced by Mosque and Fard No. 4 Pollens on the Size of Deglet Noor Dates and Seed. (Millimeters.)

	FRUIT		SEED	
	Length	Breadth	Length	Breadth
1925 & 26 (24 experiments)	2.8±0.19	0.9±0.10	3.0±0.12	1.0±0.05
1927 (38 experiments)	2.4±0.14	0.4±0.07	2.7±0.10	1.1±0.03

TABLE V—Net Dry Weight of Flesh (Fruit Minus Seed) per 100 Deglet Noor Dates Produced by Different Pollens in 10 Experiments in 1927—Each on a Single Bunch. (Grams.)

Experiment	Mosque	Fard No.4	Difference	Percentage increase
1.	827.3	722.0	105.3	14.6
2.	658.4	633.7	24.7	3.9
3.	750.4	667.6	82.8	12.4
4.	729.0	663.9	65.1	9.8
5.	795.7	751.2	44.5	5.9
6.	800.1	769.6	30.5	4.0
7.	796.4	673.3	123.1	18.3
8.	865.8	763.6	102.2	13.4
9.	855.8	824.4	31.4	3.8
10.	757.9	693.6	64.3	9.3

TABLE VI—Weight of Seeds per 100 Deglet Noor Dates Produced by Different Pollens in 10 Experiments in 1927—Each on a Single Bunch. (Grams.)

Experiment	Mosque	Fard No.4	Difference	Percentage increase
1.	113.1	64.0	49.1	76.7
2.	101.7	65.8	35.9	54.6
3.	110.5	72.8	37.7	51.8
4.	126.3	64.4	61.9	96.1
5.	118.6	79.0	39.6	50.1
6.	108.1	63.4	44.7	70.5
7.	116.6	68.7	47.9	69.7
8.	109.6	74.1	35.5	47.9
9.	106.6	75.1	31.5	41.9
10.	96.2	74.3	21.9	29.5

Evolution of the Domestic Animals

ENTSTEHUNG DER HAUSTIERE, BY B. KLATT. Handbuch der Vererbungswissenschaft, adited by E. Baur und M. Hartmann, Part 2. 15 marks. Gebrüder Borntraeger, Berlin, 1928.

THIS book gives a short exposition of the problems concerning the descent of the domestic animals. About two thirds of the publication is taken up with general considerations regarding the influences of domestication and the different methods of inquiry into the problems of the evolution of breeds of domestic animals. Three phases of the subject clearly present themselves; the psychological problem of how the wild animal became domesticated; the physiological question of the influences of domestication upon the body of the animals, and the history of domestication. The latter is concerned partially with biological problems (data of comparative anatomy and hybridization and of serological tests contributing to our knowledge of the ancestry of our present breeds) and partially with the historical records of earlier times providing information about the appearance and fate of animals as man's companion. The last part of Klatt's contribution gives a short account of the special questions connected with the evolution of the principal types of domestic animals.

Throughout the book the author admittedly bases his presentation upon his own viewpoints. Everywhere, however, credit is given to opposing opinions. This undoubtedly makes the book interesting reading for all who are in position to judge the soundness of the author's reasoning. On the whole one can hardly escape the impression that our knowledge scarcely permits any firm opinions concerning the questions under consideration. In many cases, however, heterogeneous data tend to offer suggestive evidence, and for geneticists provide material for fascinating, so probably not very fruitful, speculation. Klatt favors the viewpoint that ("minor") genetic traits played a relatively unimportant rôle in the descent of domestic animals, and he believes the main factor for the origin of domestic breeds to be rather sudden constitutional changes. Klatt is aware of the fact that this assumption is not in harmony with present genetic evidence, but unfortunately he does not state his reasons for believing that such constitutional (endocrinal) changes are something fundamentally different from ordinary mutations. Fifteen very interesting original photographs add to the value of the book. *Walter Landauer*

The Inheritance of Nervous Diseases

ERBLICHKEIT UND NERVENLEIDEN, *by* F. KEHRER. 1. Ursachen und Erblichkeitskreis von Chorea, Myoklonie, und Athetose. Pp. 136, with 6 illus. and 54 pedigree charts, price M.18. Monographien aus dem Gesamtgebiete der Neurologie und Psychiatrie, Heft. 50. Berlin, Verlag von Julius Springer, 1928.

A valuable source of material on all phases of the subject. The author emphasizes the fact that the manifestations of such a disease as Huntington's Chorea are different in each family, presumably because of the influence of modifying genes.

P. P.

METAXENIA IN THE DATE PALM

Possibly a Hormone Action by the Embryo or Endosperm

WALTER T. SWINGLE

*Senior Physiologist, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.**

THE recent introduction of the finest old-world varieties of the date palm into this country has provided opportunity to study this giant monocotyledonous tree from many aspects. In attempting to establish the culture of the date palm on a large scale in the hot irrigated valleys of the southwestern states, especially California, Arizona, Texas and Nevada, it has been found necessary to study by modern scientific methods the age-old practices of the Arabs in growing date palms in order to give the American farmer, quite lacking in any experience in growing arboreal monocotyledons, a sufficient body of information to enable him to proceed rationally with the culture of this new crop. Although the culture of the date palm is one of the oldest fruit industries, dating back some five thousand years in Mesopotamia, so little scientific research has been done on this plant that it was, when introduced into the United States at the beginning of this century, probably the least studied and certainly the least understood major crop plant grown outside of the tropics. Thanks to active work along physiological, chemical and practical cultural lines carried out by the Bureau of Plant Industry of the U. S. Department of Agriculture, the University of Arizona and by private institutions and individuals, it is no exaggeration to state that accurate botanical and cultural knowledge of the date palm has been accumulated at so rapid a rate that doubtless more has been learned about the date palm during the past twenty-five years by a handful of scientific investigators, than had been learned in twice twenty-five centuries by the millions of date growers of the Old-World.

The practical advantages accruing from applying modern scientific methods of research to the study of the date palm and its culture, have been most evident, but it should be noted also that the study of this new and striking crop plant has yielded some most interesting and significant results to the biological sciences.

I need only cite the striking results published by Mason which show the date palm to have a remarkable stability of temperature in its single deep-seated and well protected growing point —the date palm is in fact almost a "warm-blooded plant." He showed also that the date palm grows only at night or during cloudy weather and that growth was almost instantaneously arrested by the sunlight of desert regions but was not stopped by artificial light of equal or even greater intensity but free from ultraviolet radiation.[6,7]

I wish to bring to your attention today an even more striking discovery undoubtedly of profound significance in physiology and genetics, that has recently been made in the course of research work on the date palm and its culture, initiated, as noted above, to create a body of demonstrated facts adequate to guide the American date growers in lieu of the inchoate body of traditional, semi-instinctive, rule-of-thumb practices of the Old-World date growers.

The date palm is the classical example of a dicœcious tree and the ancient Greeks early recognized the two

*This paper was presented at the annual meeting of the National Academy of Sciences at Washington, D. C., April 24, 1928.

sexes of this plant. In a state of nature roughly half the seedlings of the date palm are male and half female. The ancient Sumerians several milleniums before the beginning of our era discovered artificial pollination and even made it an important part of their religion, as revealed to us by the splendid wall-carvings in bas-relief found in the ruined cities of Mesopotamia. This discovery almost doubled the production of dates per given area by permitting the destruction of all but a very few male palms, thereby allowing the date gardens to be planted almost entirely to female fruit-bearing palms.

Artificial pollination is now practiced in all date growing regions by people of many different races. As a rule, only two or three per cent of the date palms are males, almost all being females.

First Observation on Metaxenia

About five years ago in the autumn of 1922 and again in 1923, I noticed that a certain seedling date palm growing at the U. S. Experimental Date Garden at Indio, California, produced fruit of two classes having seeds differing greatly in size. It was commonly believed by date growers at that time that the male parent had an effect on the size of the seed and it was suspected that the very small seeds observed in part of this fruit had been produced by pollen of a male palm nearby that had grown from a seed of the Fard date, a variety produced in the Semail Valley in Southeastern Arabia, noted for the very small size of its seeds.

The following spring, four years ago, in 1924, pollen from this male was sent to Mr. Laurence M. Huey, a date grower who had in his date garden at Bard, California, a female seedling grown from a Fard date seed, in the hope that the use of this particular pollen might reduce the size of the seed and make it more like the imported Fard date.

The female Fard seedling palm was not in flower when the Fard pollen was received and Mr. Huey used it on another seedling female palm which produced very large dates (the Fard variety has small fruit as well as small seeds). In the autumn of 1924 Mr. Huey, fortunately a trained observer, a skilled ornithologist and mammalogist, reported that the dates on his palm pollinated with pollen from the Fard seedling male were much smaller than the other dates on the same tree pollinated with pollen from a male palm growing nearby. I secured samples of the fruit and found a very decided difference in the size of the fruit accompanied by even greater differences in the size of the seeds—the pollen of the Fard male making very small seeds and small fruits, that of the other male palm making very large seeds and large fruits.

In the spring of 1925, a definite study of the effect of various pollens on the size and character of the seed and fruit was undertaken under my direction by Mr. Roy W. Nixon of the staff of the U. S. Experiment Date Garden at Indio, California, while I, myself, tested the Fard male pollen in a small garden of Deglet Noor dates in the hope of securing small seeds then considered to be advantageous.

I also tested in bagged flower clusters a few other sorts of pollen, including the pollen from Mr. Huey's ranch that had produced, in 1924, very large seeds in contrast to the very small seeds produced by the Fard seedling male.

By the middle of July, Nixon discovered an unexpected effect of the Fard pollen in causing early coloring of Deglet Noor dates.* Dates of this variety are green until nearly full size, then they turn vivid carnelian red until just before they begin to ripen when they lose their vivid color and slowly assume the honey color of the ripe dates.

*This and other varieties of the date palm are propagated vegetatively by detaching offshoots that are produced at the base of the stem.

It was soon found by Nixon that the dates pollinated by Fard pollen not only colored earlier than those pollinated by "Mosque" pollen* used for comparison but also, as was to be expected, ripened earlier.

I likewise found a marked difference in time of ripening of Deglet Noor dates on which I had used Fard and Huey pollen—the Fard pollen caused very much earlier maturity than the Huey pollen used on another carefully bagged bunch on the same palm which happened to hang on the same side of the palm at the same height and so was exposed to the same climatic influences.

In this particular instance most of the dates pollinated with Fard No. 4 pollen were ripe or partly ripe by the middle of September while only very few of those pollinated with the Huey pollen were ripe before the first of October. Nixon used different kinds of pollen on the very same bunch of fruit and used absorbent cotton to seal his bags so there could be no doubt as to the accuracy of his results which show a decided influence of the male parent on the size of the seed, the size of the fruit and on the time of ripening of the fruit.

Results of Experiments

Nixon has recently published two papers[9,10] giving a full account of his work which shows striking differences in size of seeds and fruits and in the rate of development and time of ripening of the fruits of the Deglet Noor date pollinated with pollen from different male palms.

The following example (Table 1) gives a good idea of the influence of particular kinds of pollen on the length of the seeds and length of the fruits observed by Nixon.[9] (p. 117, exp. No. 5).

The difference shown in this experiment between the length of date fruits pollinated with Mosque and Fard No. 4 pollen was 2.47 mm. and in length of seed 3.53 agreeing closely with the average differences observed in 1925 and 1926 which were 2.2±0.3 mm for the fruit in 1925 and 3.4±39 mm in 1926 and 3.1±0.25 mm for the seeds for 1925 and 3.1±0.21 in 1926.

The effect of different male palms on the rate of development and on the time of ripening of the fruit was shown very strikingly by Nixon's experiments.

The change of color from green to bright carnelian red which is the first sign of approaching maturity in the Deglet Noor variety of date was greatly hastened by the use of Fard pollen and delayed by using Mosque pollen.

For example in experiment No. 5 a Deglet Noor flower cluster was pollinated on March 20 and March 25 with several kinds of pollen. On July 27 the following percentage of the fruits showed a faint pink color:

Mosque pollen .....17 per cent colored
Fard No. 4 .....83 per cent colored

The differences in time of ripening

TABLE I—Length of fruits and of seeds of Deglet Noor dates on same bunch, pollinated with two different kinds of pollen

Pollen Used	Length of fruits 34	35	36	37	38	39	40	41	42	43	44	45	mm.	Number Measured	Mean length
Mosque				1	1	2	8	9	14	4		1		40	41.17 mm.
Fard No.4	2	1	4	2	9	9	5	4	2	2				40	38.70 mm.

Pollen Used	Length of seeds 19	20	21	22	23	24	25	26	27	28	29	30	mm.	Number Measured	Mean length
Mosque					1	1	4	7	12	10	4	1		40	26.98
Fard No. 4	1	1	4	7	8	7	6	3	3					40	23.45

*Pollen from a very vigorous male date palm grown from a seed from a date palm growing in Egypt collected by S. C. Mason and called in his notes Mosque date.

of Deglet Noor dates pollinated from different males was equally marked as is shown by experiment No. 6 in 1926. In this case a fruit flower cluster was pollinated on March 23 and examined on Aug. 17, Aug. 27, Sept. 3, Sept. 13, and Sept. 30 with the results shown in Table II.

As noted by Nixon there seems to be a rough correlation between the size of seed, size of fruit and time of ripening induced by pollen from different male plants of *Phoenix dactylifera,* the pollen which induces the formation of large seeds and large fruits, causing late ripening and that giving rise to small seeds and small fruits inducing early ripening.

Curiously enough no such simple correlation exists between the size of seed and fruit and the time of ripening of the fruit when pollen of other species of Phoenix is used. For example one male palm of *Phoenix canariensis* (No. 3) which caused even later ripening of Deglet Noor dates in 1926 than the latest pollen (Mosque male) of *Phoenix dactylifera* tested that year produced smaller seeds than any *dactylifera* male tested. In his experiment No. 2 Nixon[9] (p. 108) used pollen of male palms known as Mosque, Fard No. 4, and *Canariensis* No. 1 applied to bunches of one Deglet Noor tree within three days from February 24 to February 26 and on September 30 the percentage of ripe fruit was as follows:

Pollen used	Date of Pollination	Percentage of ripe fruit
Mosque	Feb. 25	87.4
Fard No. 4	Feb. 26	92.0
Canariensis No. 1	Feb. 24	64.0

The Canariensis pollen was used on a flower cluster that opened 2 days before the one on which the Mosque pollen was used, nevertheless only a little more than three-fourths as many dates ripened with the *Canariensis* pollen as with the Mosque pollen which causes as late ripening of the fruit as any *dactylifera* male yet studied.

Yet the fruit and seeds resulting from this experiment showed the *canariensis* pollen to have produced smaller seeds and fruits than even the Fard No. 4 pollen, which produces the smallest seeds and fruits of any *dactylifera* male studied and also causes the earliest ripening of the fruit.

This is shown in Table III (from Nixon[9] p. 117, Exp. No. 2.)

One of the most remarkable actions of the pollen on the rate of development of date fruit was that observed by Nixon[10] in applying pollen of the dwarf ornamental palm, *Phoenix Roebelenii,* to flowers of a Deglet Noor date palm (*Phoenix dactylifera*). This pollen was applied April 25, 1927, and on the same palm a similar flower

TABLE II. Time of Ripening of Deglet Noor Date Fruits

Pollen Used	Number of fruits	Aug. 17 Percent. ripe & partly ripe	Aug. 27 Percent. ripe & partly ripe	Sept. 3 Percent. ripe & partly ripe	Sept. 13 Percent. ripe & partly ripe	Sept. 30 Percent. ripe & partly ripe
Mosque	98	2	15	22	48	95
Fard No. 4	83	18	47	57	93	100

TABLE III--Length of fruits and seeds of Deglet Noor dates

Pollen Used	Number measured	Average length seed mm.	Average length fruit mm.
Mosque	100	26.44	40.90
Fard No. 4	100	23.84	39.28
Canariensis No. 1	100	21.47	37.27

cluster had been pollinated April 21, only four days previously, with mixed pollen of *Phoenix dactylifera,* including Fard and Mosque pollen, from the two males causing the greatest difference in the time of ripening of the fruit.

By the middle of October, 1927 many dates were ripening on the fruit cluster pollinated with mixed *dactylifera* pollen, while all the fruit on the bunch pollinated with *P. Roebelenii* was still entirely immature. By November 19, all the fruit on the fruit cluster that received *dactylifera* pollen was ripe and only about five per cent of that pollinated with *Roebelenii* pollen. On December 5, only eighteen per cent of the dates pollinated by *Phoenix Roebelenii* were ripe and thirty-three per cent partly ripe, nearly half being still still immature—a delay in ripening of at least one month and probably of nearly two months. More than one-third of the seeds of this hybrid show a dorsal depression about the germ pore where the embryo is located. Nixon suggests that possibly this is caused by some inhibition in the development of the endosperm in the vicinity of the embryo. The embryo itself was found by him to be smaller than the normal embryo of *Phoenix dactylifera* and on planting the seed very few germinated. The seeds and fruits of Deglet Noor dates resulting from the use of *Roebelenii* pollen are both of medium size, larger than those produced by Fard pollen and smaller than those produced by Mosque pollen.

The amount of difference in the time of ripening of dates due to the action of different kinds of pollen varies with the temperature at the ripening season. Dates ripening late in August or early in September at Indio, California, may mature very rapidly at high temperatures prevailing at that season.

On the other hand dates ripening late in autumn when temperatures are lower show much greater differences in time of maturity due to the use of different kinds of pollen, owing to the slowing down of the ripening process by low temperatures.

It should be said that the fruit of the date palm can in many varieties (the Deglet Noor is one of them) ripen even if not pollinated, in which case it contains no seed or at least only a very imperfect seed without endosperm or embryo. Such unpollinated dates always ripen very late but are usually much more slender than normal dates that contain good seeds. This would seem to indicate that the metaxenic action of the secretions of the fertilized elements of the seed act to hasten the development of the fruit that would nevertheless ripen eventually without such stimulus. This would mean that the hormone-like substances secreted by the embryo or endosperm are not necessary to cause the fruit to ripen—they merely hasten its ripening.

In addition to the very definite differences in the size of seeds produced by pollen from different male date palms, Nixon has discovered[9] (p. 126, fig. 7), marked differences in shape of the seeds induced by the pollen of *Phoenix canariensis* used to fecundate the female flowers of the true date palm, *Phoenix dactylifera,* and has also found differences in the color of the seeds produced by the pollen of different male palms, all of them true date palms, *Phoenix dactylifera.* These differences in shape and color are due to metaxenia as they are shown by tissues of the seed outside of the embryo and endosperm.

No such differences in color, shape, texture or quality have yet been observed in date fruits produced by pollen of different males, only size, rate

*The thought occurs that possibly the *Roebelenii*×*dactylifera* hybrid is the result of too violent a cross to develop normally and that possibly the weak hybrid embryo that often fails to germinate did not secrete the usual quantity of hormones during its development and consequently the ripening of the fruit was not given the usual stimulus; this hypothesis would presuppose an influence exerted on the development of the fruit by the developing embryo.

of development and time of ripening being influenced.

The first announcement of the discovery of the direct effect exerted by date pollen on the fruit of the date palm was made at the meeting of the Southwestern Division of the American Association for the Advancement of Science at Phoenix, Arizona, February 15, 1926, in two papers, one a joint paper by Nixon and me on the facts observed, and one by me proposing the name metaxenia for this direct effect of pollen on the date fruit and suggesting a possible explanation of its causation.

These two papers [18, 19] were amplified and presented at the International Congress of Plant Sciences at Ithaca, August 16-23, 1926. Fresh dates shipped from California to Ithaca in cold storage were exhibited to show the extraordinary effects of different pollens on the size and on the time of ripening of the fruit.

The essential paragraph of my abstract published by Thone[22] reads as follows:

> The double fertilization of the egg cell and the endosperm mother cell explains satisfactorily the influence of the pollen on the date seed itself, this being a form of xenia. However, the striking influence on the size, shape, character, and time of ripening of fruit cannot be explained by the theory of xenia, but apparently necessitates the recognition of influences in the plant body analogous to those exerted by ductless glands in the animal body. The simplest hypothesis is that the embryo, or the endosperm of the date seed, or both together, constitute a ductless gland apparatus that affects, by secreting hormones, the whole development of the date fruit, including tissues belonging morphologically to the mother plant, and especially to the thickened ovary walls which constitute the edible portion of the date fruit.

This constitutes the first published notice of metaxenia and of my theory of its cause.

It has long been known that seedless parthenocarpic fruits often differ greatly in size and shape from those that are pollinated and bear fertile seeds and the date palm itself is an excellent example for such a demonstration as unpollinated dates often develop to large size, in some varieties being larger than normally pollinated fruit, but are always of different shape (being much more slender) and usually ripen much later.

The effects observed by Nixon and me are of a very different character—viz. a great variation in the size and time of ripening of the fruit due to the different action of different kinds of pollen *all of which cause normal development of the seed and fruit!*

The effects observed on the seed are not so surprising since a large part of the date seed is composed of the endosperm which develops from a nucleus in the embryo sac with which a nucleus from the male parent has united. In other words, the date seed is largely of hybrid origin and should show characters of the male parent not only in the small embryo but in the much larger endosperm.

No such explanation will suffice, however, to make clear the action of the male parent on the development, time of ripening and size of the date fruit which consists exclusively of the somatic tissue of the mother plant no single cell of which contains any chromatic matter of the male used to pollinate the fruit.

I well remember many years ago securing striking proof of the immediate action of pollen on the character, shape, size and color of maize kernals and I well remember how baffling this result was and how impossible it proved to understand or even discuss intelligently this immediate effect of pollen on maize, until the discovery of double fertilization in the higher plants lead to the almost immediate recognition of the nature of xenia in maize and other plants.

The double fertilization of the higher plants was discovered by S. Nawaschin[8] in 1898, and next year de Vries[23] and Correns[3] showed clearly that xenia in maize could be explained by the fertilization of the endosperm by the second generative nucleus of the pollen tube.

From this time on xenia became a clearly understood, completely proved phenomenon to be studied like any other phenomena occurring in plants.

Tentative Explanation of Metaxenia

In the present case we have the astonishing fact of direct action of pollen on the size, the rate of development, and the time of ripening of the fruit of the date which consists of the ovarial tissues of the mother plant! Xenia as it occurs in maize and other plants will explain in part at least the effect of pollen on the date seed, but it is powerless to explain any action on the ovary wall of the mother plant of which the date fruit is composed. Firmly convinced that these striking facts regarding the strange and hitherto unobserved action of pollen on the date fruit discovered by Nixon and me could not be explained by any existing theory of genetics or physiology, I have felt it necessary to give a name to the phenomenon and to search for some possible explanation of it.

In order to be able to refer to this newly discovered action of pollen on the ovarial tissues of the mother plant without begging the question as to the explanation of such action, I proposed at Phoenix, Arizona, in February, 1926, the term metaxenia to designate the action of the male parent on tissues of the mother plant outside of the embryo and endosperm. The term metaxenia is formed, of course, by analogy with the term xenia, which denotes the influence exerted by the male parent on the endosperm of the seed.

It seems to me desirable to propose a theory to account for the metaxenia observed in the date palm since such a theory will enable us to consider the facts in the light of the theory and either confirm and prove it or else invalidate and disprove it, thereby making way for the true explanation.

It seems to me that the simplest theory to explain metaxenia is to assume that the embryo or the endosperm or both of them secrete one or more soluble substances (analogous to the hormones secreted by the ductless glands of animals) that influence the development of the adjacent ovarial tissues of the mother plant in a definite manner.

The embryo and the endosperm are both composed of cells the nuclei of which contain chromosomes derived from the male parent. These two fertilized elements of the seed should, therefore, be expected to show the influence of the male parent. The seed of the young developing date fruit is in intimate contact with the tissues of the endosperm, and it is highly probable that soluble substances secreted by the embryo or endosperm could and would diffuse freely from the seed into the nearby tissues.

It is to be noted that metaxenia is shown by those parts of the seed outside of the embryo and endosperm, but is not limited to this short range but is, in the date at least, exercised over the entire ovarial tissue of the mother plant often distant as much as several millimeters, or even as much as a centimeter, from the nearest embryo or endosperm tissue in which the male parent is represented by chromosomes.

Francis E. Lloyd in his remarkable paper[5] on the development of the date seed published eighteen years ago showed conclusively that the embryo and the endosperm of the date exhibit remarkable changes in tannin, oil and reserve cellulose content during the development of the fruit.

At first—the endosperm is full of tannin, for some eight or ten weeks from the time of fecundation up to the time when the endosperm, until then a syncytial sac is cut up into cells that soon fill the whole sac. During this latter period lasting some four weeks the tannin disappears more or less completely from the endosperm and oil which had appeared at about the seventh week after pollination increases slowly in amount until the newly formed walls of the endosperm begin to show progressive thickening due to

the deposition of reserve cellulose. As the thickening of the cell walls begins the oil content diminishes and the tannin again reappears. From now on until the seed ripens the oil increases until it constitutes 7-9% of the weight of the seed; reserve cellulose also increases greatly, while tannin, which reappears in large amounts by the twelfth week, begins by about the fourteenth week to diminish and is almost wanting in the ripe seeds.

This astonishing *va et vient* shows that, far from being an inert mass of reserve cellulose, the endosperm during its development is the seat of active and strangely varied chemical changes.

The embryo has a simpler history though strange enough. The young embryo, like the young endosperm, shows abundant tannin up to about the thirteenth week, when it is about one-third to one-fourth grown; from this period on the tannin diminishes slowly and finally disappears as the embryo matures. Up to about the eleventh or twelfth week the endosperm shows no striking peculiarities in its development, but from the thirteenth to the seventeenth week the embryo grows rapidly and attains nearly its full size. This involves complicated mechanical adjustments with the even more rapidly growing endosperm, in which the embryo is imbedded and what is more important from our standpoint, the digestion of the endosperm cells that come in contact with the growing embryo. Oil now abundant in the endosperm, disappears in the cells near the embryo, being apparently consumed by it. Lloyd[5] (p. 159) considers that the "appearance of oil in any part of the embryo is correlated with the relative cessation of activity in that part."

The developing embryo, according to Lloyd, also digests the primary cell walls of the adjoining cells of the endosperm, but this action ceases as the embryo matures, and the germinating embryo does not dissolve the primary cell which appears to persist (as the middle lamella) after the germinating embryo absorbs the reserve cellulose of the endosperm.

It is clear, therefore, that powerful ferments are secreted by the developing embryo which differ from those secreted by it when germination begins.

The complex changes in the starch, sugar, and tannin in the carpel need not be discussed here. Oil is absent, but the complex interplay of the other food materials indicates that intense chemical activity reigns in the carpel as well as in the seed.

Some plant physiologists doubt the presence of hormones in plants and certainly doubts may be held as to the wisdom of using the name hormones* with all its animal physiological implications for the soluble substances which have been proved to influence growth in many plants. That such a growth promoting substance or substances occur cannot now be doubted, in view of the concordant testimony of a large number of plant physiologists of many countries.

Other Hormone-Like Substances in Plants

The classical example of a hormone-like substance in plants is the "growth stuff" formed at the very tip of the coleoptile of germinating grasses which is able to diffuse through sterile gelatine or silica gel and still influence growth.

The first proof of this was given by Boysen-Jensen in 1910[1] and 1911[2].

This discovery of Boysen-Jensen was confirmed by Paál in 1914[11] and worked out more fully by him in 1919[12].

In 1923 Söding again confirmed the previous discoveries and applied the name hormone to the diffusible sub-

*The substances secreted by the embryo or endosperm able to affect profoundly the developmental history of the date fruit are perhaps more like hormones than the growth-stuff secreted in the coleoptile tips of the grasses and in other plant organs.

stances, able to stimulate growth, that are found in the tip of grass coleoptiles, and in a very recent paper he answers adverse criticisms and again maintains that growth hormones have been proved to exist in many plants.[17]

Very many investigations have been made on this subject during recent years culminating in two remarkable papers by Went[24] published in 1926 and in 1928,[25] of which the last is a 116-page treatise full of ingenious original work, but also with a 6-page bibliography of previous work in this field containing 82 titles, 74 of them published after Boysen-Jensen's first paper was issued in 1910.

In this admirable paper Went shows that the tips of the coleoptiles of germinating oat seedlings secrete a "growth stuff" that migrates down the seedling and causes growth insofar as the cells are in condition to grow. The most striking demonstrations are those where cut-off coleoptile tips are placed on gelatine into which in the course of 30-120 minutes the "growth stuff" diffuses. Then a bit of this gelatine placed on one side of the top of the decapitated coleoptile causes curvature by inducing one-sided growth!

Still more striking was the dilution experiment when the gelatin plates containing "growth stuff" were placed on similar slabs of unimpregnated gelatine and left there a few hours until the "growth stuff" had diffused equally through both pieces. Then one of these blocks of gelatine placed on one side of a cut-off coleoptile *caused only half the curvature of an undiluted gelatine block!* Such dilutions if made only one-quarter as strong as the original block cause only one-quarter the curvature.

Went also proved that the size of the piece of impregnated gelatine within certain limits had no effect on the amount of curvature, provided that the larger and smaller pieces contained the same amount of "growth stuff." Went, like Paál (1919) is convinced that phototropic curvatures are caused by the same "growth stuff" that causes upright growth in uniform light or in darkness through the action of the light in favoring the production of "growth stuff" on the side away from the light and hindering it on the side toward the light. Went brings strong evidence to prove that the "growth stuff" is a relatively stable substance that does not lose its activity by heating for a few minutes to 90°C, which he considers as proof that it is not of an enzymatic nature. He also found it was slightly if at all injured by alcohol. Its rate of diffusion shows its molecular weight to be rather large (of the order 300-400) about that of the molecule of cane sugar.

During the past few years hormones or "growth stuffs" similar to that of the grass coleoptiles have been found by Beyer[25] in seedlings of dicotyledons and by Söding in developing flower stems.[16]

Many other actions at a distance have been considered by plant physiologists of repute to be due to hormone-like substances some of them stimulating growth and other inhibiting growth. An example of the latter is, according to Reed,[13],[14] the action of the terminal bud of pears, lemons and other plants in preventing the growth of nearby lateral buds on the same twig.

In view of the intense physiological activity of the developing embryo and endosperm of the date seed, it seems likely that hormone-like substances do diffuse out to the ovarial tissues and cause the direct action of the pollen demonstrated so thoroughly by Nixon in the two papers cited above.

It is very probable that metaxenia will be found in many other plants besides the date, especially where the developing seed is in close contact with the tissue that ripens into a fruit.

It is possible that a metaxenic influence of the male parent may be found to extend into the tissues of the mother plant beyond the carpel, but as yet clear and unequivocal proof of such influence is not at hand.

That the pollen may influence the development of the ovary is well known in some of the orchids where the ovules are not fully differentiated until after pollination has occurred. This direct action of the pollen on the tissues of the mother plant may be analogous to metaxenia, but needs more study and, above all, a study of the possible different action of different kinds of pollen before it can be classed as a case of metaxenia.

It is probable, too, that other actions analogous to metaxenia may occur in some cases, perhaps in many cases. It is a very curious fact that the supernumerary embryos of Citrus which develop from cells of the nucellar tissue of the mother plant growing into the embryo sac, as discovered by Strasburger[18] do not develop in any haphazard way but come to resemble almost exactly true embryos as they have cotyledons, the special and characteristic first leaves and even the spines* characteristic of seedling Citrus plants developing from true fertilized embryos.

Similar supernumerary false-embryos occur in the Mango and in some other plants. It looks very much as if some hormone-like substances were formed in the embryo sac apparatus that constrain the nucellar bud to develop like a true embryo.

In some Citrus hybrids for example the Rusk citrange,[21] a first generation hybrid of the common sweet orange, *Citrus sinensis* Osb. and the trifoliate orange, *Poncirus trifoliata* Raf., the true embryo is unable to develop, i. e., the citrange is a sterile F_1 hybrid, yet if pollinated with Citrus pollen the Rusk, Morton and other sterile citranges develop a few or sometimes many seeds containing only false-embryos derived from cells of the nucellar tissue of the mother plant. This gives rise to the paradox of sterile F_1 hybrids reproducing exactly from seed!

It seems possible that the development of false-embryos in Citrus and other plants is, in effect, an action the reverse of metaxenia as defined above and the embryo sac apparatus of the mother plant may profoundly influence the development of the embryo whether it is a normal embryo resulting from the fecundation of the egg or a false embryo formed from a cell growing into the embryo sac from the outside.

Summary

The pollen of the date palm, *Phoenix dactylifera*, and of other species of Phoenix, has been found to exert a direct influence on the size, shape and color of the seed, and also on the size of the fruit, on the speed of development of the fruit and on the time of ripening of the fruit of the vegetatively propagated female varieties of the date palm.

This direct influence of the male parent on the development of the date fruit is precise and definite and varies with the particular male used to fecundate the female flowers. each male exerting approximately the same effect on fruit of all varieties and exerting the same effect in different years.

This direct effect of the pollen on the parts of the seed and fruit lying outside the embryo and endosperm is called metaxenia.

Metaxenia, unlike xenia, cannot be explained by hereditary elements (chromesomes) brought in by the pollen as no such chromesomes occur in the tissues that show the direct effect of the pollen parent.

The simplest and most probable theory to explain metaxenia is that the embryo or endosperm or both of them secrete hormones, or soluble substances analogous to them, which diffuse out into the tissues of the mother plant that constitute the seed and fruit and there exert a specific effect on these tissues varying according to the particular male parent used to fecundate the embryo and endosperm.

*And this, regardless of whether the mother plant was a nearly spineless variety or not.

Evidence is adduced to show that the embryo and endosperm of the date show remarkable chemical activities during their development and interact to some extent on each other and probably on the nearby tissues of the seed and the surrounding ovary walls that constitute the fruit.

Soluble substances able to influence growth are shown to occur widely in plants and some at least are substances that can diffuse into gelatine or silica gel and from such a matrix diffuse back into living tissues where they exert a direct specific and measurable influence on the growth of the tissue so stimulated.

Metaxenia is doubtless not limited to the date palm, but probably occurs in many plants and may conceivably be exerted in some cases on tissues of the mother plant outside of the seed and fruit.

An action analogous to metaxenia but apparently in the reverse direction seems to occur in Citrus and some other plants where supernumerary embryos that arise from cells of nucellar tissues and grow into the embryo sac are profoundly influenced by the embryo sac apparatus of the mother plant and develop almost exactly like the true embryos resulting from a fertilized egg, although they are merely vegetative buds of the tissues of the mother plant that invade the embryo sac and develop there.

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An Introduction to Eugenics

The Builders of America, *by* Ellsworth Huntington and Leon F. Whitney. Pp. 368, illus., $3.50 net. Willian Morrow and Co., New York, 1927.

Professor Huntington, a geographer who has made notable contributions to the study of racial questions and Mr. Whitney, secretary of the American Eugenics Society, have collaborated to produce one of the best popular accounts of eugenics that is available for the general reader. The treatment is constructive throughout, special emphasis being placed not on the negative but on the positive side of the eugenics program. Good use is made of *Who's Who* in presentation of information concerning the size of families, and it is shown that at the top of the ladder there is an increase in the number of living children. Within this limited class, at least, the eugenic desideratum actually exists—a positive correlation between social and economic status and size of family. As compared with most popular works on eugenics, which are mere compilations, however good they may be, this work contains an unusual amount of new material. It is therefore one which no student of the subject can afford to overlook.

P. P.

AN ACTIVE LIFE, OR A LONG ONE?

A Review

LIBRARIANS and publishers are agog over the increased quantity of serious reading done by the American public. According to report, instructive books covering many different phases of learning are giving a battle to the lighter forms of literature. This is interesting, if true. Personally, I am a pessimist,—at least as regards science. Out of some fifty books for the general public purporting to be psychology that I have recently examined, two-thirds appear to have written by voodoo worshippers. From a still larger number of volumes on biology, chemistry, physics, and their applications, I find less than half a dozen which give the impression that the authors are acquainted with their subjects. Yet if one were to believe the high-voltage "blurbs" written by the publishers, this scrivening is serious stuff, indited by the world's most celebrated thinkers.

The truth is, an accurate tally would probably show only a moderate increase in the circulation of really authoritatives works of a graver character. It is better so, if the choice is to be between the high-grade fiction now appearing in this country and appeals to the higher cerebral centers by ignoramuses and confidence men. On the other hand, there is a plenteous supply of informative, thoughtful books written by master hands, and there is a demand as evidenced by the sale of the sludge mentioned above. Why do the two so seldom meet? I suspect that it is the fault of the publishers. The old conservative houses, with long lists of books having solid worth, fail to advertise them; the mass production firms are inveigled into pushing nonsense forward as gospel because their mentors on science and the like, if any, seldom are able to distinguish between an Isaac Newton and an Adolphus Mutt.

The inspiration for these remarks is the recent book by Dr. Raymond Pearl, with the title "The Rate of Living."* It is so different from the publications usually found under Science in the trade circulars of houses dealing primarily with belles lettres. It is a detailed account of fundamental studies on the duration of life which is scholarly without being technical, and lucid without being written down to the lowest levels of human intelligence. Those who wish only to be entertained or amused had better avoid it. But it would be difficult to recommend a book which shows more clearly or more satisfactorily how the scientist goes about his job. No one can read it and not be less likely to be goldbricked in the purchase of serious books thereafter; for he will be able to recognize the proper formulation, treatment, and analysis of a scientific problem.

The book describes a series of experiments upon the behavior of colonies of the common fruit fly. The material was presented in substantially the same form in three lectures delivered at University College, London, in June 27, 1927. The object of the experiments was to parallel the vital statistics of the human race upon a short-lived organism of known heredity that would breed freely in captivity. Only by such studies can one obtain a reasonably clear idea of the biological factors involved in the evolution of human societies.

Many interesting facts emerge. The fruit fly has an expectation of life in the adult stage that is about the same in days as that found for

*The Rate of Living, by RAYMOND PEARL. New York: Alfred A. Knopf. 1928.

man when expressed in years. Moreover, the life tables take the same form. When conditions are varied by changing the food supply or improving the ventilation, slight changes in the mean duration of life are obtained; but these public health measures have a rather insignificant effect. On the other hand, density has a marked effect. "There can be no question that the degree of crowding of organisms together in spatially limited universes has a profound effect upon various vital processes. This is quite an argument for the Malthusian, though he must not carry his conclusions too far, for there is a limit to the degree of crowding having an adverse effect upon life, above which increased density produces no further reduction.

Perhaps the most interesting conclusion that can be drawn from the work is that longevity is inherited. The life curves of different strains of flies of known genetic constitutions are decidely different. And when crosses are made and the resulting populations studied, the data obtained are exactly those to be expected on the basis of the chromosome theory of heredity. In other words, duration of life is to be regarded as the summation in time units of the organization of the individual, in the Aristotelian sense; and it is this organization that is inherited.

If one may transfer these conclusions to the human race, therefore, what one may say is simply this: Other things being equal, long-lived people will come from long-lived stocks. They must have inherent vitality. This vitality must be thought of as a potential capacity to perform vital actions. It is a function of the organization of the individual, and is determined largely by genetic constitution. Beyond this, the relation between rate of living and duration of life is an inverse one. If we live fast, we will probably not live so long. We must balance the fun we will have in an active existence against a probable longer life of innocuous desuetude.

E. M. East.

Physiological Genetics

PHYSIOLOGICAL THEORIE DER VERERBUNG, *by* RICHARD GOLDSCHMIDT. Pp.. 247, with 59 illus. Price (bound) M.16.50. Berlin, Verlag von Julius Springer, 1927.

In the early days of Mendelism, most geneticists were content to seek for new breeding ratios, but for the last twelve or fifteen years, at least, the trend has been continually toward following the action of the genes from zygosis through to the final phenotype. Perhaps the most promising line of attack has been that following from the quantitative theory of sex, and the work of Dr. Goldschmidt, principally in crossing races of gipsy moths, has been one of the outstanding contributions to this subject.

Generalizing his results in this field, he now attempts to apply the principles to the broader field of genetics as a whole. The action of the gene is regarded as a chemical one, and much importance is ascribed to the precise time at which various reactions occur during the course of development. There is nothing new about Dr. Goldschmidt's views in principle; in detail he often goes ahead of the known facts in attempting to create a definite mechanism of heredity; nevertheless, the book is remarkably stimulating and suggestive, an important guide-post along the road which genetics is apparently destined to follow for some time to come.

Paul Popenoe.

SUCCESSFUL MEN HAVE LARGER FAMILIES

Further Evidence for Mental Evolution

F. A. Woods

IN the July, 1927 issue of the JOURNAL OF HEREDITY, I put the title of my article in the form of a question, "Is the Human Mind Still Evolving?" I do not believe that it will be necessary to put it as a question again, for the evidence is now very considerable that humanity is evolving mentally,—at least that a certain small percentage is doing so. It has been discovered that there are forces akin to natural selection silently at work, almost unperceived, yet leading towards an inevitable mental evolution.

There is now every likelihood that the statement, *Mental evolution is going on today,* holds true for at least certain social classes in most civilized countries. Whether it is also true for the lower classes remains to be seen.

In the records of Harvard graduates I found "success" correlated with large families. In other words those who had the greatest number of living children were the ones most apt to achieve that form of success exemplified by inclusion in *Who's Who in America.* Such a fact is only part of a general sociological and historical tendency that I have been studying for a number of years. It is all to be predicted on theoretical grounds. The reader can find this discussed in my *Influence of Monarchs,* 1915, and some actual proofs of the process in the last chapter of *Mental and Moral Heredity in Royalty,* 1906. Some further evidences were given in a statistical study of aristocracy in Boston and its neighborhood which was published in the proceedings of the Second International Eugenics Congress held in New York in 1921. This article was given the title, "Social Conification." The word conification is used to express the idea of an evolution taking place at the top of the social cone.

Some further proof seemed desirable; the Harvard records were found, in 1925, to confirm the facts as exhibited in the history of the royal families and the New England families. This was announced in the *World's Work* for November, 1926, page 32.* Since then I have found the same survival of ability within the British peerage, and I am interested to learn that a number of other investigators have brought in results all of which lead to the further conviction that this is, as far as it goes, a general or inevitable tendency in the rise of nations.

As far as the British peerage is concerned the detailed proofs have not been given, though the results have been announced in *Science.* I would like to present here the data in a sufficiently detailed way. This will make it possible for anyone interested (or anyone doubtful) to examine the method and check up the results.

The well known *Burke's Peerage* is for present purposes a good book for primary factors. I have divided all the peers (edition of 1921) into two groups; first those whose male lines are traceable as early as 1450, and second, those whose male lines are not traceable to such an early date. This bears on the average some relationship to the date of elevation to the Peerage; but that is another matter.

These in the first group are the peers who belong to the very old male lines, "old families," so called. They constitute nearly half of all the peers. Their family names are well known to everyone conversant with English history.

*Article written by A. E. Wiggam.

As regards their achievements which must be in a considerable degree due to a mixture of ability, vitality and ambition, they have all been placed in two groups, and compared only with each other. First a comparatively small group who have done nothing or next to nothing in the way of rendering public service; and second, a majority group whose public services appear to have been both genuine and continuous. Naturally there are border-line cases difficult to place, but these are not very numerous and I have been careful to adjust the doubtful cases in such a way that they would count against rather than in favor of my theory. Only those over 34 years of age have been included.

All who have been elected members of parliament or who have risen in the navy to the rank of commander, or colonel in the army (not honorary colonel), also those who served in the Great War have been included in the "service" group as well as the few business and professional men. Both *Burke* and the English *Who's Who* have been consulted for each case. Generally speaking if there is anything in their biographies that can be called "service" they have been included in this group.

Some examples are the following. These are taken systematically in order to give a fair idea of how a division has been made between "service" and "non-service" peers. Among the older families the first under letter A, "service group," was a member of Parliament from 1900 to 1913. The second under the same initial was a president of the Territorial Force Association, Lord Lieutenant of Ireland and Governor General of Canada. The first under initial B held the offices of Parliamentary Secretary, Secretary for Scotland and Chancellor of a University.

In the same way to illustrate the "non-service" group the first under initial A, older families, has no service recorded except that of lieutenant in the yeomanry. He was in 1921 about seventy years of age and the owner of 50,000 acres of land. The next under initial A appears to be distinguished in no way other than as the owner of 35,000 acres. Under initial B we find the first of the "non-service" group to be a member of the Carlton, Turf, and Marlborough Clubs. He held at one time the rank of captain in the army, but as he was over sixty years of age in 1921 and mention is made of no other public service he is here included in the "non-service" group. The second example under initial B, older families "non-service" was a man about this same age who was a lieutenant in the Royal Navy for a very short time.

In spite of considerable liberality of inclusion in the "service" group there are about 68 among the peers of the newer families whose achievements appear to be either nothing at all, or very inconsiderable. These have 138 living children which gives an average of 2.03.

There are about 274 peers of the newer families who come within the "service" group. These have 640 living children or an average of 2.33. An even greater rise is to be found in favor of the greater fecundity of the peers who have rendered "service" when we summarize the facts concerning the older families. Here about 70 peers with little or no public service to their credit, have 131 living offspring or an average of 1.87, while 210 "service" peers have 610 living children. The average for living children here rises to the surprising height of 2.90.

These figures are only approximate and are as announced in *Science*. The corrected totals, virtually the same, show that 526 "service" fathers have 1,283 living children while 135 "non-service" fathers have 263. The averages are 2.44 for the "service" against only 1.95 for the "non-service" or one ratio is about 25 per cent greater than the other. There are over six hundred and fifty individuals on one side of our totals and over 1,500 on the other. Considering the amount of difference, the number of cases is sufficient to prove the main point of the research.

A sample from the "Newer Fami-

lies" whose peerage title begins with A is here given in Table I. The dates of birth of the peers living in 1921 have been taken down in each instance so as to be sure that age does not enter into the matter. This is important in order to avoid a possible statistical fallacy.

If the "service" group had achieved their success, distinctions, honors, etc., partly because of their advanced age it might be that because of their greater age they also averaged to have more living children. As a matter of fact the differences in age between the two groups is so slight as to be negligible. Unless the peers were at least 35 years of age they were not included in these lists. The "Non-Service" peers average to have been born early in the year 1862. The "Service" peers, late in the year 1860. There is less than two years difference. One group is about sixty years old on the average and the other about sixty-one. The wives of the peers average presumably well over fifty years. Evidently there will not be many additional children born to either of these groups. Even two years advantage in age could account for only a very small part of the differences here found. The "Service group" has in proportion about one-fourth (25.1 per cent) more children than the "non-service."

If in thirty years the parents have had less than three offspring, in one year they would have an average of less than one-thirtieth of three or less than one-tenth of one. This would occur chiefly during the ages of greatest fecundity,—say from twenty-five to thirty-five years. Therefore in these groups it amounts to almost nothing.

In Table I we find that the "newer families" with "service" under the first letter of the alphabet furnish a little over two living children for each instance, 57 for 25 peers. Let us now record the newer families (non-service) also for the letter A (names not given here).

There are only five of them. The dates of the births of the fathers and the number of children are, as follows: '36, 2; '67, 2; '70, 2; '66, 5; '68, 3.

This makes 14 children for 5 cases or nearly three apiece. It is interesting because it shows how a statistical truth is often masked because of insufficient data. The totals for all of letter A, show however the "service" group leading 2.78 to 1.99 (see Table II).

This is about the way the figures run throughout the alphabet from A to Z. No more tables will be given in detail as such statistical presentation is wearisome and unnecessary. Enough has now been printed to illustrate the method. I will now give only the totals for each letter separately, combining the results from the older and the newer families. This will make it possible for anyone to check my data in a short time by taking any letter at random. Service of an official nature such as military, naval, civil and parliamentary is apparently recorded in *Burke* with completeness and detail, but it is necessary to supplement this with the English publication *Who's Who* for all

TABLE I—Newer Families, "Service." The Letter "K" Indicates a Son Killed in War

Title	*Date of birth*	*Number of Children* *Male*	*Female*
Aberconway	'50	K-1	2
Abercromby	'41	0	1
Aberdare	'51	K-3	3
Abinger	'76	0	0
Addington	'83	0	0
Airedale	'63	0	7
Aldenham	'46	1	2
Allenby	'61	K-0	0
Ancaster	'67	2	2
Anglesey	'85	0	4
Annaly	'57	1	2
Anslow	'50	0	2
Armaghdale	'50	0	0
Armstrong	'63	1	0
Arran	'68	2	0
Ashbourne	'68	0	0
Ashcombe	'67	KKK-3	0
Ashfield	'75	0	2
Ashton	'42	0	1
Ashton of Hyde	'53	1	2
Askwith (Baron)	'61	0	1
Astor	'79	4	1
Atholstan	'48	0	1
Avebury	'58	0	0
Aylmer	'42	3	2
Totals		22	35

57 living children, 25 peers

cases that do not show service in *Burke*. By this means one can add to the "service" group a small percentage of men who have some claim to inclusion on the score of business activity or authorship. Burke, who never forgets to mention any connection with a titled family higher than the one treated, even if rather remote, is somewhat negligent about allusions to literature and trade.

The complete table (Table II) shows the facts for each letter of the alphabet,—the initial refers to the family title (not family name) as listed in Burke's "Complete Peerage" for the year 1921. To the left are placed the "service" group to the right the "non-service."

Practically every time, for every letter of the alphabet, the "service" group can be seen to beat the "non-service." For the letters E, M, and N the "non-service" leads, but only by very slight margins. This examination of the elementary parts that go to make the whole in a statistical enquiry is usually instructive. The consistency of the elementary parts in this research is very convincing that we are dealing with a reality.

As is well known the British aristocracy lost many of its sons in the World War. I thought it would be valuable to make a record on this point and incorporate it in the data. The numbers of living male offspring and living female offspring are given in the two columns. The sons killed in the Great War or in any other war have been noted by a letter K. These include all those whose deaths are attributed to warfare whether they were killed in action or not. The late war took a great toll in the peerage, nevertheless the breed as a whole appears to be maintained. The 661 peers included in this research lost 100 sons,—certainly a high degree of sacrifice. The more distinguished of the peers here called "service group" lost proportionately more than the less distinguished. Five hundred and twenty-six "service-group" lost 87 sons. One hundred and thirty-five "non-service," lost only 13, or the ratio is about 16.5 to 9.6 against the better of the two classes.

Here is an instance of the dysgenic influence of war, but in spite of it all, the greater fecundity of the group which has the better record for intellectual achievements is able to more

TABLE II—Showing Totals for Each Letter of the Alphabet

	"Service"	*"Non-Service"*	*"Service"*		*"Non-Service"*	
	Average offspring	*Average offspring*	*Peers*	*Children*	*Peers*	*Children*
A	2.78	1.99	36	100	12	23
B	2.61	1.75	38	99	12	21
C	3.26	1.50	57	186	14	21
D	2.73	1.70	37	101	10	17
E	2.09	2.17	21	44	6	13
F	2.69	2.00	16	43	4	8
G	2.48	1.83	25	62	6	11
H	2.62	2.50	39	102	8	20
I	3.38	no cases	8	27	—	—
J	2.00	no cases	3	12	—	—
K	2.71	2.50	14	38	2	5
L	2.12	1.71	33	72	7	12
M	2.23	2.28	30	67	17	39
N	2.46	2.50	13	32	6	15
O	2.11	no cases	9	19	—	—
P	2.67	0.50	18	48	2	1
Q	2.00	no cases	1	2	—	—
R	3.07	2.00	32	83	6	12
S	2.60	2.50	50	130	10	25
T	2.16	1.75	12	26	8	14
V-Z	2.65	1.20	34	90	5	6
Totals	2.44	1.95	526	1283	135	263

than compensate for losses sustained in war. This seems astonishing. It shows how strong the relationship is between "success" and large surviving families.

A Paradox in Historiometry

There is a question of method in all historiometric work that needs to be discussed. There have been criticisms from time to time of some of my publications which criticisms though natural enough have arisen from the lack of understanding of statistical interpretation, especially the influence of errors.

Errors are but natural to human kind. Errors are everywhere, and blunders unfortunately also are not strangers to most of us, but whether the blunders and errors are or are not significant, is in each research a question by itself. Some people think that because the elementary (or primary data) are not like bricks and wooden planks that can be accurately weighed and measured, nothing can be done in the way of building a permanent scientific superstructure. But these people are entirely wrong. The present research is as good as another to illuminate this picture of how a good construction in the domain of scientific probability may arise from elementary material known to be faulty. Just as in studying the history of royalty, so here in the history of the peerage, we are relying in part on the opinions of others and in part on our own interpretation of these opinions.

What sort of errors are thus introduced? Have they any probable false bias towards giving us the unwarranted conclusion that here in the British peerage there is a survival of ability? As for statements of the compilers (their printed records in the two books of reference) evidently there could be no conscious or unconscious bias toward the results here obtained. For instance, it is inconceivable that whenever they saw that a man had a lot of children they were more careful to give him a complete record for public service. Such a bias as this could only come to someone who already had a theory similar to my own. An investigator seeking to confirm a theory is, as is well known, unconsciously liable to move the data in a way favorable to conclusions that he already has in mind. That is why in this research it is necessary to present the data in such a way that any other person (a critic or sceptic) can take a portion at random and check the work as a whole. The place of danger is my own separation of the two groups, "service" and "non-service." That is why it is essential to give enough detail to enable another person to check the research by taking any portion at random and making their own classification. There is one error in this particular study which is undoubtedly present and an adequate consideration of the same is interesting and instructive.

Undoubtedly many, or at least some of the peers placed in the "non-service" class have lived quiet lives, managing their own estates and caring for the welfare of their tenants. They have sometimes lived better lives intellectually and morally than some of those in the service group. If by some other method one could discover these superior members of the "non-service" group we have now a reason for expecting that they would show a greater number of offspring than the "undesirables," club-loafers, and such, within the same group. This we have a right to believe, because a series of former researches have pointed in such a direction. I refer to the correlations I found in royalty, 1906, Harvard graduates, *World's Work*, November, 1926 (confirmed by J. C. Phillips in the Harvard Graduates Magazine for June, 1927. Harvard graduates again in detail, JOURNAL OF HEREDITY, July 1927, and also others.

This chain of researches all pointing towards a general correlation both of mental and moral qualities within the individual and of increased fecundity with both mental and moral superiority, within any small homogeneous group, indicates that the same is there masked within the "non-service" group.

Therefore, the logical conclusion is:

if our method had been more ideal we would have the truth even more strikingly presented. Instead of finding one group with 25 per cent more offspring than the other we might, with a more perfect method of classification, find it, say, 30 per cent. It is no use to go back and say this research contains errors. The more errors it contains the more we must suppose that the relationship, correlation, or general truth that we have discovered is really greater than it here seems to be.

That is of course only so if the errors can, with justice, be supposed to have no bias towards the conclusion obtained; in which case we are lead to the following paradox of histriometry. *The worse we think the material the more certain we may be of our conclusions, provided there is no bias in favor of the results.*

Researches of this nature, which at best only give us a high degree of probability, need confirmation. That is why I published my general results concerning the Harvard graduates in a way to attract more attention than if they had been published in technical detail in a strictly scientific journal. I hoped it might stimulate others to try it out on some other college records or by some different method and see if it were not true. As a general thing if a man sees a completed research he is not sufficiently interested to give the labor necessary to confirming the research of another person. If the results are represented in a rough way his scientific curiosity is more actively aroused. I had been waiting just twenty-three years for someone other than myself to either confirm or refute my conclusions regarding the survival of both ability and virtue.

Mr. A. E. Wiggam's writings are widely read and I therefore hoped that by pubilshing the general results in his articles in the *World's Work* in 1926 many people interested in eugenics might be lead to know about these optimistic facts. I therefore gave him the entire data and also, soon after, the written MS. My hopes were realized and I soon received several letters showing that interest had been aroused not only at Harvard but also at Yale. In my former article in the JOURNAL OF HEREDITY I referred to Dr. Phillips' research which was then nearing completion. His final results now published in the Harvard Graduates Magazine for June, 1927, are very satisfying. There is not a break in his series. Each grade higher than the next shows an increase in the probable number of surviving children per capita. Of his five grades, grade one is the highest in "success." The figures run as follows:

Grades	*V*	*VI*	*III*	*II*	*I*
	.74	1.03	1.54	1.76	2.02

In *Heredity in Royalty* the figures also mount from left to right though not quite so uniformly. Here is the table* showing first the correlation between virtues and the average number of offspring to reach the age of 21. Here the highest grade is ten, the lowest is one. The subjective element is practically entirely eliminated because these gradings were made for another purpose (the study of heredity) without any idea of making this special investigation.

It can be here seen that all the grades from (5) to (10), i. e., those with the higher ratings for virtues (estimated from the opinions of historians, supplemented by biographical dictionaries and standard encylopaedias) had on the average always more than three children apiece. The highest figures of all occur in the grades (9) and (10), though (10) is a little lower than (9). Those below three adult offspring, all lie at the left and the lowest of all, 1.66, occurs in the lowest grade.

That the number of adult offspring is also correlated with intellect is shown

*Grades for virtues	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Average number of adult offspring	1.66	2.86	2.99	2.41	3.44	3.49	3.05	3.03	3.93	3.80

by the following table* which proves intellect to be correlated with virtue. Except for grade (5) each figure at the right is larger than the one at its left.

The mathematical correlation for intellect with virtues is here about + .30. The probable error is small. I do not attach much importance to this figure as an accurate measure of the amount of correlation between mental and moral qualities, but the figures show clearly enough that a substantial correlation exists, and whatever there is must work towards mental as well as moral betterment.†

The figures for the Harvard Graduates, their inclusion in *Who's Who in America* correlated with their differing numbers of children should be examined carefully in the table below. For instance, in the class of '90; among all the unmarried, 15.2 per cent of these men are included in *Who's Who in America*. In contrast with this the percentage rises to 24.45 for those who have three living children.

It can be seen from the following table that the rise is not uniform for any single graduate class but that if the four are combined a sufficiently uniform rise is demonstrated to satisfy a person familiar with the significance of statistics. By adding the unmarried and married-but-childless, and dividing by two, we find that only 13.08 per cent of these persons appear in *Who's Who* against 16 to 18 for those with children.

The averages of these figures contain some error because the graduating classes are never the same size. Therefore I have also obtained the averages for the totals: unmarried, no-child, one child, etc. These figures are 8.75; 16.19; 15.91; 15.70; 17.57; 18.54. They also make a fairly good series of advances from left to right. This method, while giving proper weight to the total number of graduates, gives too little weight to the *Who's Who* inclusion. For instance, the large class of '98 has not been out long enough to have but a scattering number in *Who's Who,* which small number can not be expected to be in conformity with the rest, and should not be given undue weight. It is best to average both of these minor errors. We then get the smoothest series of the three, showing how the truth, if present, struggles to show itself above the surface and succeeds in doing so the more we refine the method.

The figures are now 9.23; 16.31; 16.41; 16.29; 18.25; 18.32. If the fourth element were a little larger every one of the six would be a little larger than the one at the left. Such series are fully as convincing as complicated "probable errors." It is evident that the unmarried are distinctly less likely to gain those forms of success leading to inclusion in this well known work of reference. Also success on the whole comes with larger families

TABLE III—Number of Children—Harvard Graduates
Both Sexes (Averaged)

	Unmarried	*0*	*1*	*2*	*3*	*4 or more*
Class of '90	15.2	19.40	22.92	18.27	24.45	14.26
Class of '92	14.75	14.10	18.75	22.81	20.76	18.92
Class of '94	6.25	20.	13.33	18.07	22.45	25.45
Class of '98	2.63	12.26	12.64	8.	8.	13.73
Averages of above	9.71	16.44	16.91	16.79	18.92	18.09
Averages of the totals in the classes	8.75	16.19	15.91	15.70	17.57	18.54
Averages of the two averages	9.23	16.31	16.41	16.29	18.25	18.32

*Grades for virtues	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Average intellectual grades	3.92	4.34	5.43	5.51	5.29	5.66	5.87	6.37	6.66	7.33

†I believe that the effect of the random errors makes this correlation lower than the truth, rather than higher. See "*Historiometry* as an Exact Science," *Science* N. S., vol. 33, No. 850, April 14, 1911, pp. 568-574, reprinted in the appendix in "The Influence of Monarchs." 1915.

though the differences are not very great. This is a purely objective statement of fact and is in the nature of a discovery. As I have said before, if the method of grading success is improved the expectation is that the facts will show themselves even more strongly. That is perhaps why Dr. Phillips' results come out even more uniformly and strikingly. But his method of grading "success" is at least partly subjective, and there is no way of telling how far an unconscious factor may have had an influence. It appears however, from his first letter to me, that he had already graded at least part of the graduates for an investigation of a different nature—one concerning undergraduate achievement and adult success. He wrote me that he saw my announcement in the *World's Work* and that this stimulated him to try the same thing with his own material. To that extent his results are even more interesting and confirmatory.

It is no use to criticize *Who's Who*. This I pointed out long ago in a controversy concerning the question of city boys and country boys as to which were the most likely to gain success in after life. This whole question can be found discussed in *Historimetry as an Exact Science* in the last part of *The Influence of Monarchs,* (1913).

Royalty Today

If all this is so, some people may wonder why royalty today is not more able than in former times. The answer is that living royalty today if traced back in an expanding pedigree on all sides is almost entirely derived from comparatively mediocre Germanic houses such as Holstein of Denmark, and the so-called Romanoffs, who are not really Romanoffs but also descend from the house of Denmark. Also another race that enters very largely in the complete pedigrees of the royal families of today is Saxe-Coburg-Gotha. This stock while containing many excellent characters like Prince Albert, the consort of Queen Victoria, has never been noted for men able in war and government.

The old brilliant breeds of royalty such as Hohenzollern at the time of Frederick the Great, Nassau-Orange in the generations following William the Silent and the house of Sweden at the time of Gustavus Adolphus left besides older sons who became kings also younger sons and of course many daughters. The younger sons and daughters were just as able as those who actually became kings. They intermarried into families of somewhat (though slightly) less importance, thus carrying away the "genius" so called, which was not genius in the usual sense of the word (original or creative genius) but merely a very high degree of ability in war and government.

In the next generation most of the children married royalty of even less importance. In a generation or two the younger sons and daughters of the lesser royal families often married into noble houses. This very likely improved the stock of these non-royal families, but it carried the "genius" further and further away from the fountain sources.

It is not as if the able royal families of the sixteenth to eighteenth centuries were a closed corporation and obliged to marry only within the able groups. If the successors to the throne had been chosen from the ablest and not from the oldest sons a very different outcome might have been expected. See also *Eugenical News* for December 1927.

Here in the records of the British Peerage I do not find that the dozen or fifteen outstanding men of the present generation have more children than the ordinary "service" group of peers. I have made the same test for the Harvard Graduates. I selected a number of graduates whose biographies were included in standard encyclopedias, but I did not find this group had more children than the average.

This would suggest that there may be a point of success, distinction, "genius," mental superiority or whatever we may call it, at which the gen-

eralization "survival of ability" does not hold true.

These laws are, however, true for the transmission of talent and for most normal and generally desirable qualities. Men in the Hall of Fame, for instance, had more distinguished relatives than those in a larger group (3,00) just below them in eminence. If the expectations for the transmission of hereditary talent are good up to the point of producing people of the type of the Hall of Fame they are good enough for most people.

The average for total offspring for all college graduates is lower than it ought to be to keep up the type. For all Harvard Graduates it averages below two. The average for all graduates, *circa* 1.5, rises for the more successful to *circa* 1.8. As nowadays among the better classes, those who want children have them, the children should themselves inherit this temperament. This is a new condition which did not, a few generations ago, act with as great a selective force as it does today. From now on this inheritance of the parental instinct should in a few generations restore the number to a little over two, which is necessary for a continuance of the breed.

Some may contend that a little over two is not enough and that it has been shown that at least three children are necessary; but it must be remembered that the records both for the Harvard Graduates and the British Peers concern *living* offspring only. The children of the Harvard Graduates must in my data be on the average about ten or fifteen years old, and the sons and daughters of the peers about thirty. Besides, in any of the well-to-do classes of society infant mortality is not very high. For the "service" peers the *survival figure* is well over two. For the best grade in Phillipps' figures it is already 2.02. For his second grade it is now 1.75.

Conclusions

My conclusions are as follows: Even if it is going too far to thus speculate on the future, it seems to me that we now have unmistakable evidence that at least within some classes of society there is a real mental and moral evolution going on today.

From other researches we know that heredity (germ-cell determination) must be usually the chief cause of important mental differences.*

As far as heredity goes there is thus a tendency to conserve rather than to decrease the human strains of greatest ability and of greatest moral worth. Such is found true in the three groups; royalty, American college graduates and British nobility. Those individuals who have more than average mental and moral ratings have more than the average number of children, rather than less than the average. It is encouraging therefore to observe that exceptional ability and virtue tend to be increased by heredity rather than to die out.

*See the researches of Galton, Pearson, Woods, Thorndike, Schuster, Terman, Kelley, Estabrook et al; E. L. Thorndike, "Educational Psychology" and Popenoe and Johnson, "Applied Eugenics."

DROSOPHILA AND HISTOLOGY LABORATORIES

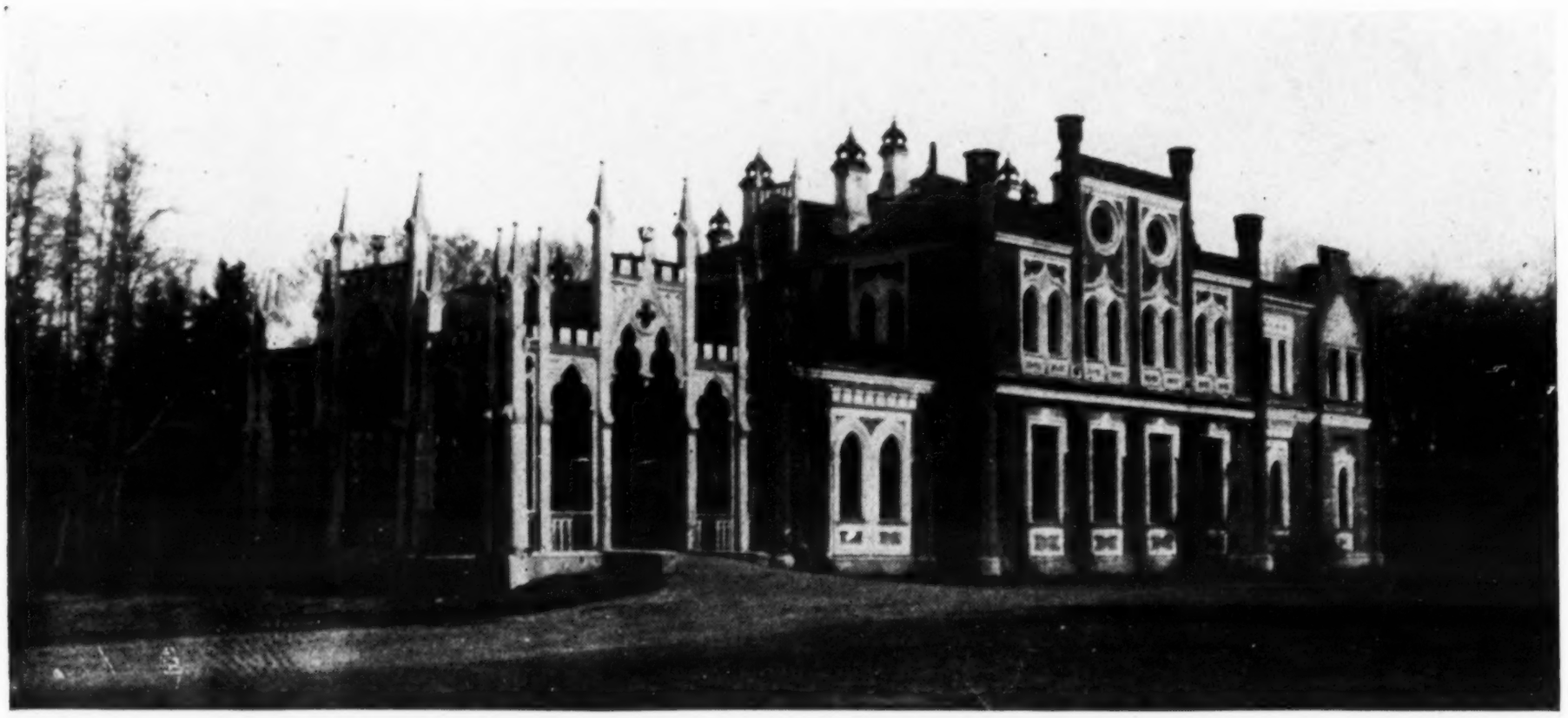
Figure 7

At Anikowo studies are in progress on the genetics of the fowl, sheep, cattle, and smaller animals.

GENETICS AT THE ANIKOWO STATION

A Russian Animal Breeding Center That Has Been Developed During the Reconstruction Period

L. C. DUNN
Genetist, Connecticut Agricultural Experiment Station



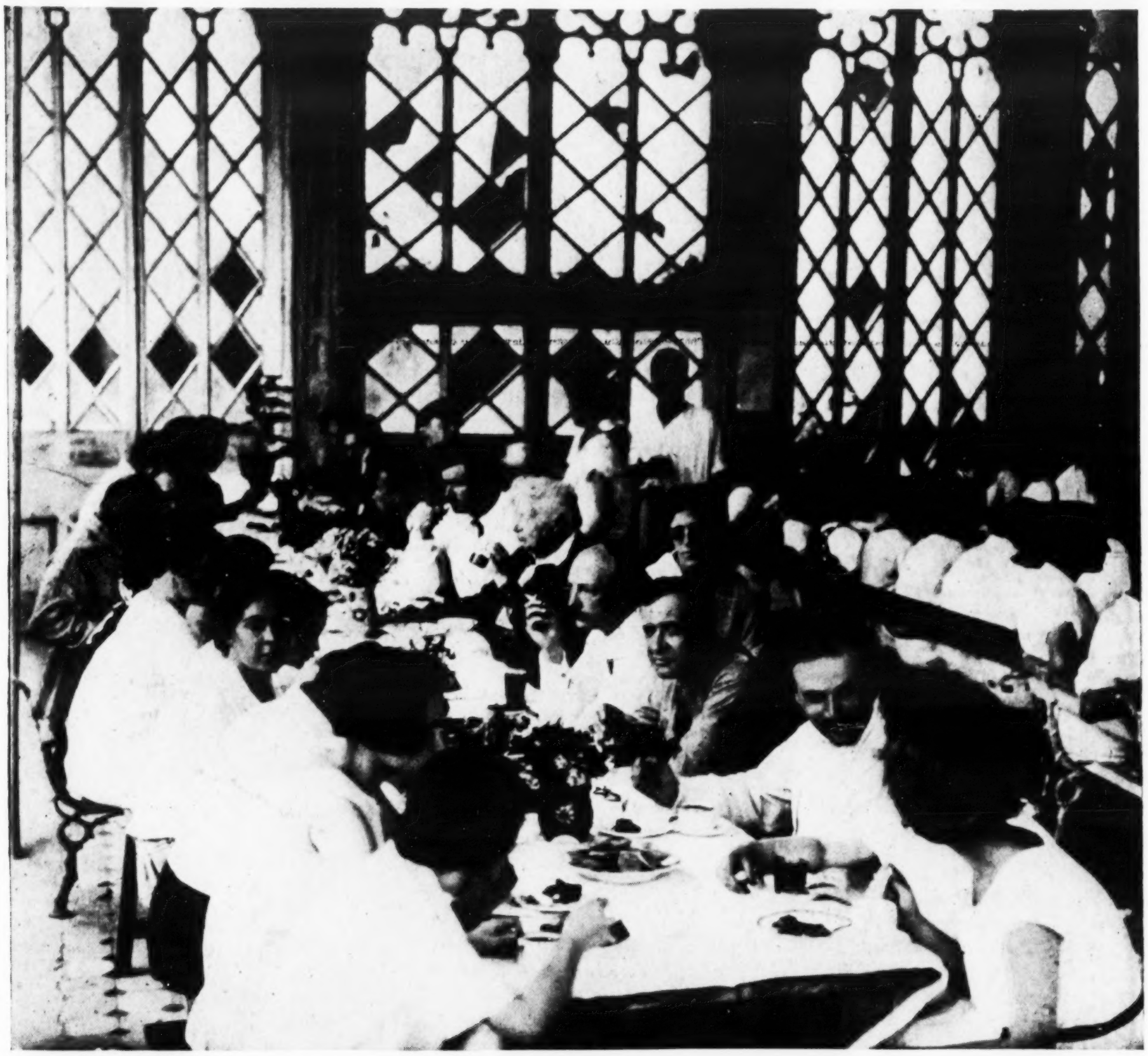
ANIKOWO RESEARCH STATION, MOSCOW

Figure 8

Founded in 1921 by merging two research stations, established in 1918 and 1919. It is significant that 1921 was a famine year in Russia. Nevertheless the workers at Anikowo made an excellent beginning and since then very valuable work has been done, with extremely slender material resources. The station is housed in the buildings of a former country estate near the village of Nasarjewo, 30 miles from Moscow. The manor house of the estate shown above now contains living quarters, laboratories and offices of the genetics station.

IN the next few issues of this Journal there will appear a series of abstracts and reviews of recent contributions to poultry genetics which have been published in Russian under the title "Genetics of the Domestic Fowl, memoirs of the Anikowo Genetical Station near Moscow." In an effort to make the new data obtained at this Station available in English, Miss Glessing of the Bureau of Animal Industry, U. S. Department of Agriculture, at the instance of Dr. M. A. Jull, has translated the entire manuscript of this memoir. Because of its length and the difficulties of publication, the entire translation will not be published, but a condensed account in abstract form has been prepared by the writer, and this will appear serially in this Journal in the near future. I must acknowledge here also my indebtedness to Miss Mary Cytovich, formerly of the Animal Breeding Research Department, University of Edinburgh, who read to me in English most of the contributions included before I was aware that Miss Glessing intended to make a complete translation. I also have had the assistance of Mr. Gabriel Lebedeff, a student in the Connecticut Agricultural College, in the work of translation and abstracting.

As an introduction to these abstracts and reviews of the work at Anikowo, a short description of the station and its research program may be of interest to the members of the American Genetic Association. This account is



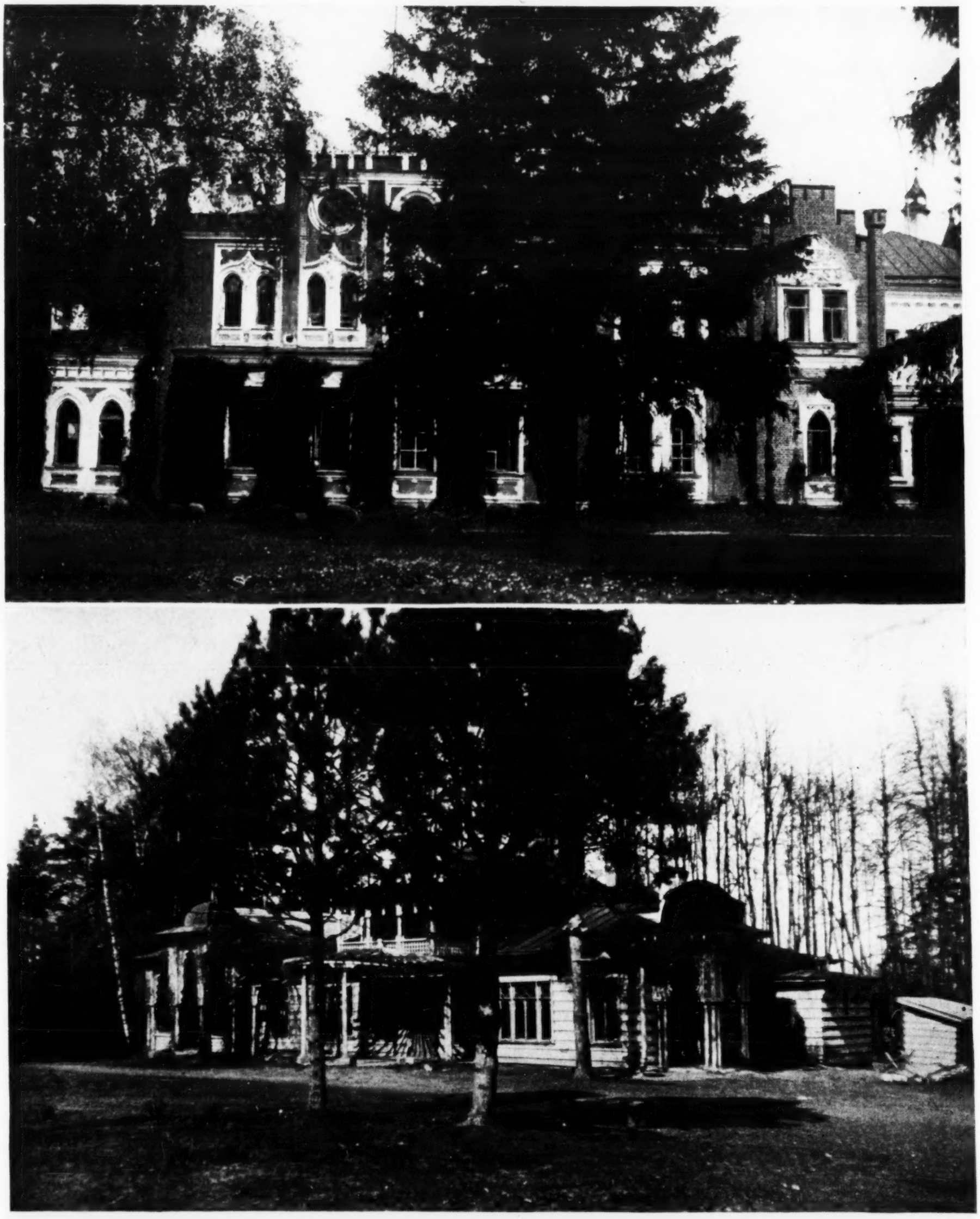
SUMMER RESEARCH WORKERS AT ANIKOWO

Figure 9

The Anikowo research station is near Moscow, and during the summer the regular staff is augmented by an influx of workers from the institute of Experimental Biology at Moscow. The summer staff of the station is shown here at dinner.

based on a short visit which I made to Moscow in the late fall of 1927, during which time I was entertained most cordially by Professor Koltzoff, director of the Institute of Experimental Biology in Moscow, and his staff, and by Dr. Serebrovsky, who is in charge of the work in poultry genetics at the Anikowo station.

The Institute of Experimental Biology in Moscow was founded in the year of the Revolution, 1917, by Professor Koltzoff. In the same year, work in genetics with poultry and small animals was begun at the Institute by Professor Lebedeff, but finding it impossible to carry on breeding experiments in the city, he moved them into the country in 1918, and established a small station near the village of Anikowo, whence the station took its name. At about the same time the Institute of Experimental Biology was made a part of the National Institute of Public Health. A second station in the government of Tula at



THE ANIKOWO STATION

Figure 10

Above is shown the main building of the Anikowo Station, formerly an estate; but since the revolution converted into a station for genetic research. Below is shown one of the outbuildings of the estate, now housing part of the research station.

the Chomjakov Zoological Park, was established under Professor Serebrovsky in 1919. In 1921 the two stations were merged into the present Anikowo station, with Professor Lebedeff as director, and placed under the joint support of the government Bureau of Animal Husbandry, which cared for the animals, the Russian Academy of Sciences, which paid the salaries of the workers, and the Institute of Experimental Biology (itself supported by the Commissariat of Public Health), which made itself responsible for the organization and the conduct and equipment of the laboratories. Again the year of the foundation is significant, for 1921 was one of the worst of the famine years, when the general economic level in Russia was extremely low. In 1924 the station was attached to the experimental department of the Commissariat of Agriculture, and placed under the supervision of Mr. W. A. Ratziborssky.

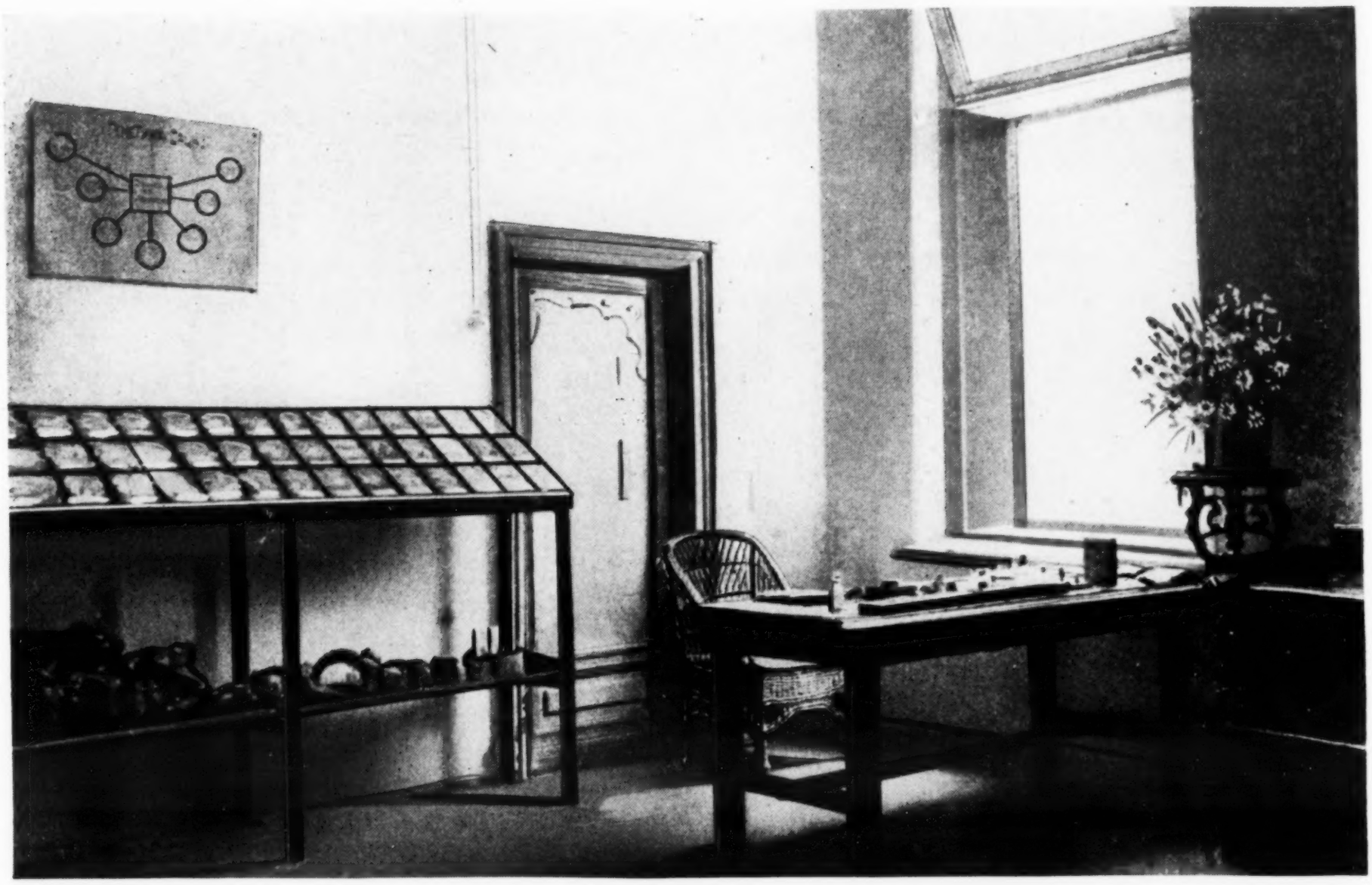
The Anikowo station is under the same directorate as the Institute of Experimental Biology, and functions in close connection with the larger institute. In the Moscow Institute, a staff of some thirty to forty research workers under Professor Koltzoff are actively engaged in studying a great variety of biological problems, most of them of direct interest to genetics. The breeding experiments, chiefly with farm animals, which require space and land, are carried on at Anikowo by a resident staff of some dozen workers. Anikowo also serves as a summer retreat for the workers from the city Institute (Figure 9).

The station at Anikowo consists of the manor house (Figure 8), outbuildings (Figure 10), and land of what formerly was a Russian country estate. It is located near the little village of Nasarjewo, some thirty miles from Moscow. The manor house provides laboratories (Figure 7), offices, a museum, and living quarters (Figure 10), for the permanent staff and summer workers. The stables and other outbuildings house the experimental flock of sheep, a large number of fowls, guinea pigs, etc., and provide space for incubation, brooding, etc. Arrangements and equipment are of the simplest. Lack of funds and the difficulties of obtaining manufactured products in general have made it necessary for the station to be to a large degree self-dependent, and much of the equipment —e.g., brooders, etc.—has been made by the workers themselves.

The chief work of the station from its foundation in 1917 has been in the genetics of color and morphological characters in fowls, under the leadership of Professor Serebrovsky, and in spite of great difficulties in obtaining pure stock and equipment and in rearing chickens under the rigorous and unfavorable climate of the Moscow district, much progress has been made. Many of the experiments began with "village fowls," heterozygous in many characters, and the results obtained often derived their chief value from careful and accurate observation and analysis of new characters which offered themselves to the investigators.

One of the chief items on the research program at Anikowo has been the detection and study of linkage in fowls, and to this end a great number of combinations of characters have been made and tested for linkage. The linkage of several sex-linked genes was early detected and studied (Serebrovsky 1922, 1926), but until the past year no good cases of autosomal linkage and crossing over could be established.* At the time of my visit the collection of fowls included a great variety of color and other morphological features, many of them new. The genetic analysis of these types had proceeded to such a point that it appeared that the investigators at Anikowo

*Preliminary figures from the work of the past season indicated a close linkage between the genes for rose comb and short legs (creeper variation) (unpublished data of Serebrovsky and Petrov in press, this Journal).



THE SHEEP GENETICS LABORATORY

Figure 11

The unimproved Russian sheep offer an amazing variety of heritable characters for genetic study. There is an experimental flock at Anikowo, and research in wool characters promises interesting results. In the case standing against the wall is an extremely interesting display of wool types.

could recognize and use experimentally more different characters than at any other station with which I am acquainted.

The collection at Anikowo and our knowledge of the geographical distribution of the characters of fowls also have been enriched by Serebrovsky's studies of the native fowl populations of southern Russia, where, in the absence of pure breeds or pure breeding, there exists an almost endless variety of domestic fowls differing in colors, patterns, comb, feathering and other morphological features. Some of these variations have been introduced and studied at Anikowo.

The study of characters of economic value, such as egg laying, have not contributed as much to the significant results of the Anikowo station, chiefly because conditions at the station and possibly the inherent ability of the stock have not been favorable for such studies. The winters are long and severe—the months from October through April may be reckoned as winter—and there is very little sunlight and much rain and snow. The region of the station is low, and the soil apparently retains water, so that the ground is often damp and soggy. To these must be added another condition that handicaps many experiments in poultry genetics, i. e., that the stocks were chosen and the breeding ordered by considerations other than selection for egg production or an attempt to develop special stocks for high fecundity. These conditions are reflected in the very low average annual production which, even for pullets, is below fifty eggs per year. It is doubtful if the inheritance of economic characters can be studied well under these conditions, and the work of poultry breeding in general must

have been made much more difficult and laborious. The results obtained in other directions hence are a greater credit to the energy and perseverance of the Anikowo workers.

It is unnecessary to describe the work of the station in poultry genetics in greater detail, since the abstracts of the published memoirs of the station will give an adequate idea of the work done.

In addition to poultry breeding, the station now is undertaking considerable experimental work with other animals (sheep, bees, and guinea pigs), and is accumulating data on the inheritance of a number of characters in cattle through the observation of the native cattle populations and by cooperation with breeders.

The unimproved Russian sheep populations offer a rich field for genetic analysis, for they exhibit an enormous variability in all characters—color, spotting patterns, horns, ear length, wattles, tail character, etc., to say nothing of the wide range of wool types from the coarse goat-like hair of the unimproved sheep of the southern provinces to the fine wool of types resembling the Rambouillet. In this department, Mr. and Mrs. Wassin have studied the inheritance of a number of morphological features, including wool, color, spotting and ear and tail length. As yet no reports on these experiments have been published in languages other than Russian. There is at present a good-sized experimental flock at Anikowo, including many of the variations listed above. Experiments and observations on wool characters in sheep now have begun, and promise to provide interesting new material.

In cattle, Miss Ivanova and others have been studying the inheritance of polymasty and of a number of color and pattern characters, chiefly concerned with spotting, from the records of native cattle populations in several districts. The existence of several new spotting genes has been established, including a dominant white face, a dominant piebald resembling black-eyed-white, spotted face and others. Considerable material seemed to be about ready for publication, and it is to be hoped may shortly be made available for non-Russian readers.

In this brief account I have made no attempt to give a complete description of the work of the Anikowo Station or of the greater Institute of Experimental Biology in Moscow, since both institutions will become increasingly familiar to geneticists through their published contributions. As an introduction to the first memoir of the Anikowo Station, I have tried merely to give American readers some impression of this new center of animal breeding research which has come into being during the period of Russian isolation from the western world. Both institutes, it should be remembered, were founded immediately after the revolution, and have lived and grown during the difficult periods of civil war, famine, isolation, and economic reconstruction. The work which has been accomplished during this period is, therefore, to be welcomed, not only for its present scientific value but also as an evidence of fortitude and scientific ardor under difficult conditions which augurs well for the future.